BRITISH SOCIETY
FOR THE
STUDY OF ORTHODONTICS

1967/8

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HEADQUARTERS

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Gardiner, J. H.
Price, A. H. K.
Ronertson, D. E.

III. Wales

Aberystwyth
Evans, W. D. P.
Barry
Hellier, R. O.
Cardiff
Brown, W. A. B.
Cousins, A. J. P.
Harkness, E. M.
Lewis, A. S.
Patel, V. J.
Seel, D.
Llandudno
Jones, J. E.
Swansea
Parry, H. L.

IV. Scotland

Aberdeen
McDonald, A. A. M.
Mason, Mrs. E. M. B.
Roberts, G. H.
Bucklyvie
White, Prof. T. C.
Dumbarton
Luffingham, J. K.
Dumfries
Baker, A.
Dunblane
Hood, M. R.
Dundee
Archibald, W. C.
McEwen, J. D.
Martin, J. H.
Munro, D.
Edinburgh
Barrie, W. J. McK.
Buchan, A.
Erskine, R. B.
Gibson, A. C. L.
Hargreaves, J. A.
Haynes, S.
Hopkin, G. B.
Logan, W. Russell
Miller, Miss M. N.
Woods, A. R. H.
Elderslie (Johnstone)
Hughes, F. J.
Glasgow
Anderson, H. A.
Campbell, J.
Clark, W. J.
Cockburn, A.
Delaney, C. J.
Houston, J. G.
MacCallum, W. A.
Thomson, Mrs. C. M.
Webster, Miss E. M.
Grangemouth
Stevenson, Wm.
Inverness
Ridley, Miss D. R.
Kirkcaldy
Mears, Miss R.
Paisley
McKechnie, R.
Stirling
McGonigal, F.

V. Ireland

Ballymena
Brenchley, M. L.
Bangor
Dallas, H. A.
Belfast
Adams, C. P.
Bonnar, Miss E. M.
Hobson, G. S.
McCartney, T. I.
Richardson, A.
Richardson, Mrs. M. E.
Taylor, Miss B.
Cork
Brown, K. H.
Buckley, L. A.
Hegarty, Prof. M.
O'Connor, P. J.
Dublin
Clinch, L. M.
Connolly-Meagher, T. A.
Dockrell, R. B.
Finn, S. D.
Fitzgerald, G. M.
Greene, E.
Keith, J. E.
Kennedy, G. F.
MacCauley, F. J. L.
Morris, V. B.

VI. Overseas Members

Australia

Adamson, K. T.
Bowden, B. D.
Cox, N. J.
Crisp, B.C.
Gerraty, B. J.
Heath, J. R.
McDonald, J. D. H.
Norton, R. Y.
Nugent, M. A. C.
Reading, J. F.
Roberts, P. J.
Rogers, P. J.
Spring, D. F.
Taylor, A. Thornton
Watson, D. C.
Wenck, R. D.

Bermuda

McAnuff, R. M.

Canada

Carpenter, I. P.
Copeland, G. P.
Croll, R. O.
Eastwood, A. W.
Franklin, G.
Fransblow, P.

Hackie, T. J.
James, G. A.
Mulligan, W. O.
Oliver, H. T.
Yip, A. S. G.

Canary Islands
Gonzalez, R.

France
Démogé, P. H.
Gugny, G.
O'Meyer, R. X.
Schouker-Jolly, M.

Germany
Lervy, Major W. K.
Paton, Miss D. A.

Greece
Bakatselos, S.
Tsaltas, G. K.

Hong Kong
Mak, K. L.
Tsang, Y. S.

India
Ghosh, A. S.
Patel, V. B.

Italy
Magni, F.

Jamaica
Lyn, M. R.

Malaysia
Chan, B. K.
Cheah, C. K.
Choo, S. B.
Choo, T. C.
Lee Chee Onn, J.
Lee Chin Kung
Leong, C. T.
Lye Thim Loke, Mrs.
Tam, M. F.
Sundararaj, Mrs. S.

Malta
Demajo, A.
Manara, G.

New Zealand
Ashby, J. W.
Bell, W. P. L.
Cook, C. C.
Gilbert, G. H.
Lang, E. T.
Valentine, H. B.
Willis, L. E.

Norway
Aamodt, A. C.
Engh, Olav
Krogstad, Olav, Jun.
Selmer-Olsen, Prof. R.

Rhodesia
Robson, F. F.

S. Africa
Braude, B.
De Muelenaere, J. J. G. G.
De Villiers, J. F.
Fainsinger, B. E.
Melville, R. G.
Miller, B.
Mizrahi, E.
Oosthuizen, L.

S. America
Abensur, J. (Peru)
Brears, O. B. (Ecuador)

Sweden
Ahlgren, J.
Billberg, B.
Granerus, R.
Granse, K. A.
Ljungdahl, L.
Lundström, Prof. A.
Mortenson, S. Å.
Pihl, Miss E. M. K.
Tegner, G.
Volmer Lind, H. C.

Switzerland
Hotz, Prof. R.

U.S.A.
Bell, L. A.
Blausten, S.
Coval, N. M.
Goldstein, M. C.
Gosman, S. D.
Gottlieb, A. W.
Grossman, R. C.
Jann, H. W.
Moss, G. W.
Pinsker, L. J.
Sachs, N. J.
Schleimer, M.

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

The following article by B. C. Leighton was first published in the *British Dental Journal* on the occasion of the Society's Diamond Jubilee. It is reproduced here by kind permission of the Editor of that Journal.

On October 21, 1907, eleven dental practitioners gathered at the practice of George Northcroft at 115 Harley Street, W.1. The meeting had been called by Northcroft to discuss the formation of a Society to further knowledge of orthodontics in this country. A facsimile of the letter of invitation to this meeting is shown in *Fig.* 1. The following members of the profession were present: J. H. Badcock, H. Chapman, M. Hopson, A. C. Lockett, W. F. Mellersh, G. Northcroft, M. Philpotts, J. Sim Wallace, J. E. Spiller, E. R. Tebbitt, and H. C. Visick.

115, HARLEY STREET,
CAVENDISH SQUARE, W.

Oct. 15th 1907.

Dear Sir,

It is proposed to found a Society having for it's object the promotion of the study of Orthodontia.

If you are sufficiently interested in the subject, will you meet me, informally, at the above address, on Monday next, Oct. 21st, at 8.30 ?

Yours faithfully,

G Northcroft

Fig. 1.—A facsimile of the letter of invitation sent to his colleagues to discuss the founding of an orthodontic society.

PROPOSING THE NAME

After some discussion it was decided to propose the name ' The British Society for the Study of Orthodontia '. This name was, however, used only until the end of 1909. Because it had been pointed out (by Carl Schelling) that the term ' orthodontia ' was an anomalous mixture of two Greek words with a Latin ending, the name was changed to ' The British Society for the Study of Orthodontics '. The title is important because it is characteristic of the approach to the subject adopted by the men who coined it. Several of them were to become world famous for their inquiries into the development of occlusion and the aetiology of malocclusion. The enthusiasm of such as G. Northcroft, H. Chapman and J. Sim Wallace as well as G. Campion and E. S. Friel was communicated to others and pervaded the deliberations of the Society.

THE MEN RESPONSIBLE

Before describing the state of orthodontics at that time, it might be profitable to look more

closely at the men who gathered in October, 1907, to prepare for the launching of the Society. As the mind which conceived the idea of an orthodontic society, George Northcroft (*Fig.* 2) must always occupy a special place in the annals of the Society. J. H. Badcock, speaking from the presidential chair at the first full meeting on January 22, 1908, drew the members' attention to the obligation the Society owed and would always

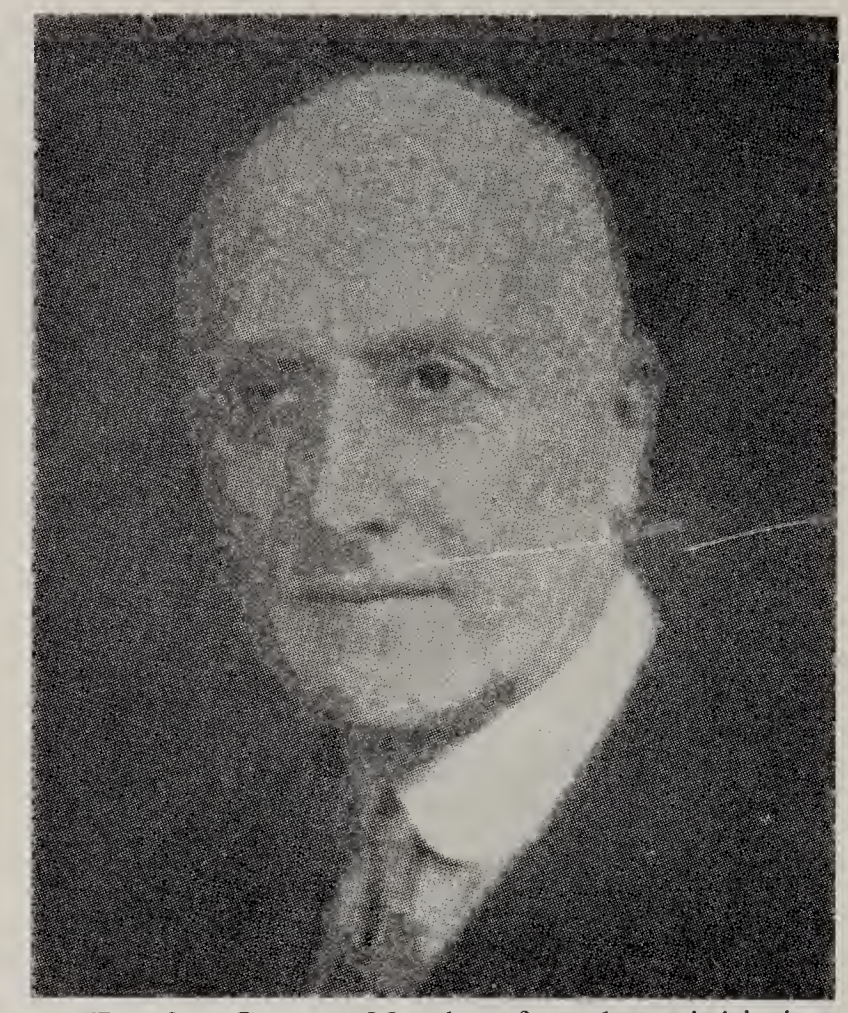

Fig. 2.—George Northcroft, whose initiative led to the founding of the Society. He was its second President.

owe, to Northcroft for the leading part he played in its inception. At the age of 39 he was still young enough to have an abundance of enthusiasm tempered with enough maturity to carry through the launching of a new society. No doubt his strong religious convictions equipped him with the necessary singleness of purpose. He had taken the unusual step of graduating D.D.S. at Ann Arbor University before studying for the L.D.S. at the Dental Hospital of London, Leicester Square. His researches were extensive and the number and variety of his contributions to the Society has only been exceeded by those of H. Chapman. His special study was the early manifestation of malocclusion, much of his knowledge being obtained from patient and astute observation. He will also, however, be remembered for his plaster plane and board (*Fig.* 3) and the face masks and dental casts he prepared of his son. These are now in the possession of the Society.

When the London Hospital decided to inaugurate a dental school, he was to become its first lecturer in dental surgery and play a leading part in its creation in 1911. The Society acknowledged its debt to George Northcroft by inaugurating an annual memorial lecture, the first of which was given in 1947.

Harold Chapman, who greatly admired Northcroft, was also a keen observer of natural growth changes in the dentition. He was the source of most of our knowledge on normal variations of

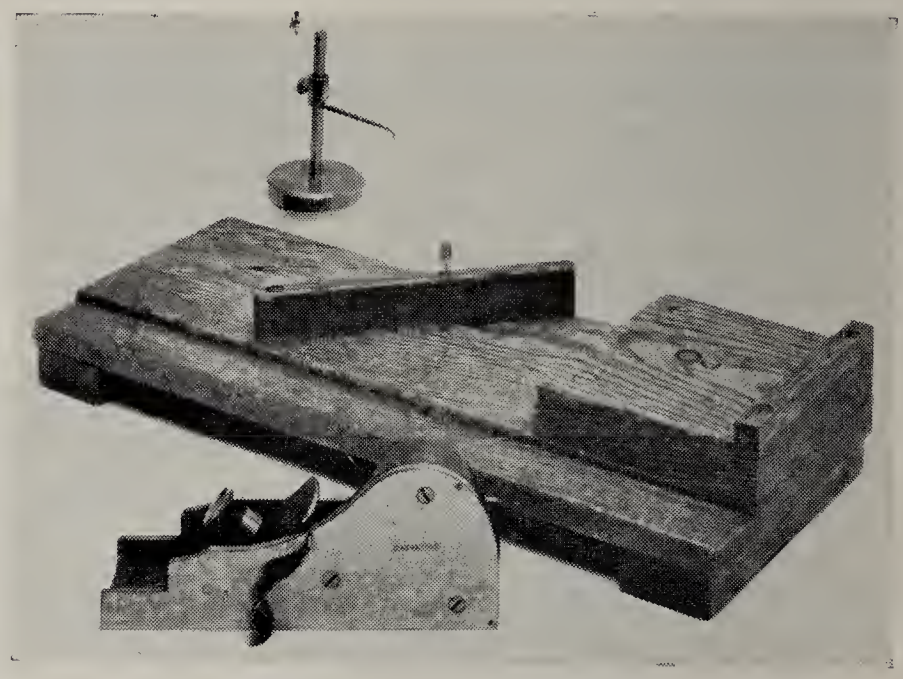

Fig. 3.—The plaster plane and board designed by Northcroft for trimming model bases. In the background may be seen the scribe for indicating the depth to which the base is to be cut.

alinement and occlusion of teeth in the mixed dentition phase of development.

At the age of 27 he was one of the youngest of the founders. He had been educated at Thetford Grammar School. After qualifying L.D.S. in Liverpool he had obtained the D.D.S. Pennsylvania before attending the Edward Angle School of Orthodontia. On his return to London he had joined Northcroft in his practice for eighteen months until he started his own in 1908. He was also on the part-time staff of Guy's Hospital in 1908, but transferred to the new Dental School at the London Hospital on its creation in 1911. It was, however, not until 1923 that he became lecturer in orthodontics. He will be remembered by many for his kind encouragement to the younger members of the profession, whom he always liked to see taking an active part in the deliberations of the Society. His memory is also perpetuated by an annual prize which the Society awards for the best essay on any aspect of orthodontics by a young member of the profession.

There are only three who have served twice as Presidents of the B.S.S.O.; both Northcroft and Chapman were among these.

FIRST CHAIRMAN AND PRESIDENT

It was not surprising that J. H. Badcock should have been elected as Chairman of the first

gathering, and later as the first President of the Society. He was the oldest of those present, and his personal charm and obvious integrity were ideal characteristics. Only three years after qualifying, in 1890, he had been appointed as assistant dental surgeon to Guy's Hospital, where his duties included instructing students in orthodontics; he resigned this appointment, however, in 1905. He practised dentistry for more than 50 years at 140 Harley Street, but his principle interest was always orthodontics. He was noted for his mechanical skill, and is still known to many for the Badcock plate and screw. His skill as a chairman was recognised by his colleagues in his election as President of the British Dental Association in 1925, and of the Second International Orthodontic Congress in 1931. The outstanding success of this Congress was due not only to Badcock's skill as a chairman but also to the preparatory work done by another founder member, A. C. Lockett.

FIRST SECRETARY

Lockett was born in Jamaica and graduated from Pennsylvania. On completion of the course at the Angle School he had been guided to England by E. H. Angle, who saw London as a fertile field for orthodontic practice. Not only was he the first secretary of the B.S.S.O., but in 1911 he became secretary of the European Odontological Society until his death in 1931.

Sim Wallace was born in Renfrewshire in 1869. Before the age of 21 he had obtained a B.Sc. in biology and the M.B., C.M. Glasgow. His early scientific background was to be reflected in his researches in later life. Being largely concerned with prevention, they earned for him the title ' father of prevention in dentistry '. As an aid to his studies of irregularity and malocclusion he introduced his prosopometer, an instrument for measuring the relationship of points in the sagittal plane to the transmeatal axis. He was elected the third President of the B.S.S.O. in 1910. In addition to degrees earned by submission of theses, he was awarded the Cartwright Prize for his essay ' Variations in the Form of the Jaws '. This is considered to be one of the classics of orthodontic literature. After holding an appointment as part-time lecturer in dental surgery and pathology at the Dental School of the London Hospital, he became part-time lecturer in preventive dentistry at King's College Hospital.

On leaving school at Newbury, Montagu Hopson was admitted as the first student at Guy's. Soon after qualifying he had been appointed assistant dental surgeon and later consulting dental surgeon, lecturing in dental anatomy and physiology. His honours were to include the presidential chairs of the Odontological Section of the Royal Society of Medicine, the British Dental Association, and, in 1913, of the B.S.S.O. One of his most important tasks was the evidence he gave, with Sir Norman Bennett, before the Interdepartmental Committee preparing for the 1921 Act. It has been said of him that his oratory was so good he would have made a good actor.

FIRST TREASURER AND LIBRARIAN

W. F. Mellersh had started his career at the Dental Hospital of London, Leicester Square in 1896. Before the turn of the century he had demonstrated his inlay technique and was probably the first to introduce the use of inlays to this country. He was well known for his technical dexterity. After being the first Treasurer of the Society he became President in 1915.

J. E. Spiller was one of the youngest of those gathered at 115 Harley Street, being little more than 26 years. He became the first librarian of the Society and was later elected President in 1916.

These brief sketches are perhaps enough to show the rich variety of talents that were assembled at the meeting on that 21st day of October. Several were to gain high honour outside the Society, but almost all were to make major contributions to the Society they were conceiving. Their influence on the course of orthodontic teaching still reaches us today.

FIRST GENERAL MEETING

The first general meeting of the Society was purely a business meeting and was held in the premises of the Medical Society of London at 11 Chandos Street, W.1. on December 5, 1907. J. H. Badcock as Chairman for the meeting explained ' the motive of those that were instrumental in bringing about the idea that an Orthodontia Society should be formed; of those that had taken part in its preliminaries. The idea in forming the Society was not to make it one of a body of specialists, but to so organise its working as to meet the needs of the general practitioner so that the profession could meet on a common ground to elucidate the problems of orthodontia '.

Although it was eventually agreed the Society should be completely independent, the by-laws were modelled closely on those of the Odontological Section of the Royal Society of Medicine. The following were elected as officers of the Society for 1908:—

President	.. J. H. Badcock.
Vice-Presidents	.. G. Northcroft, Dr. J. Sim Wallace, M. Hopson.
Secretary	.. A. C. Lockett.
Treasurer	.. W. F. Mellersh.
Curator ..	.. H. C. Visick.
Editor ..	.. W. Rushton.
Librarian	.. J. E. Spiller.
Councillors	.. E. R. Tebbitt, H. Baldwin G. Campion.

The next general meeting was held on January 22, 1908, to hear the inaugural address given by the President. It was on this occasion that Northcroft described his plaster plane.

ORTHODONTIC KNOWLEDGE AT THE TIME OF FORMATION OF THE SOCIETY

It might be of interest to the reader to examine the state of orthodontic knowledge at the time the Society was formed. Throughout the nineteenth century, dentistry had been developing as a science and gaining recognition as a necessary part of medical care. By the turn of the century there were three dental schools in London and five in other cities of the British Isles.

Knowledge of growth and development of the jaws and face had been placed on a sound footing by the work of Hunter in 1778. Joseph Fox in 1803 had given an excellent account of the treatment of crowding including the use of serial extractions. A number of textbooks published around the middle of the nineteenth century dealt at some length with the aetiology and treatment of irregular teeth and teething problems. One of the soundest of these was written by W. Imrie in 1834. In spite of its rather misleading title '*The Parents Dental Guide*', this small book would offer much to the present-day student. It contains one of the earliest descriptions of a cast lower inclined plane. Before the Society was founded in 1908 several books dealing solely with orthodontics were to be published in this country. In 1900, J. F. Colyer published his *Notes on the Treatment of Irregularity in Position of the Teeth*. This book is more substantial than its title suggests and gives an excellent account of tooth irregularities and their treatment. A generous selection of appliances made in vulcanite is shown. Many of the springs bear remarkable resemblance to those in current use. In 1904, Sim Wallace had published his work on *Irregularities of the Teeth* dealing more with aetiology than with treatment. At this time Edward Angle's influence on orthodontic thought was gaining strength in the United States. In 1900 he had formed the American Society of Orthodontists and opened the Angle School of Orthodontia. Several leading British orthodontists had visited him in the United States and returned with some of his ideas and much of his enthusiasm.

It is remarkable in reviewing the Society since its inception in 1908, to find how little its nature has changed. In the early years the meetings are notable for the ambitiously large number of communications and papers that were included in the programme. On several occasions the discussions had to be adjourned to a subsequent meeting. Perhaps one of the most notable events in the history of the Society was the publication in 1922 of its report on orthodontics in dental education. This included a definition of orthodontics which reflects the broad attitude of the early members of the Society to the subject.

In 1942 a select Committee was established to consider 'either in their present or post-war implications, problems of orthodontic teaching, research and treatment'. The report of this committee was not completed until 1944 when it was submitted not only to the Society and deans of dental schools but also to a national committee set up under the chairmanship of Lord Teviot to make recommendations on the structure of the Health Service. There is no doubt that this document together with its appended minority report has been a strong influence in guiding the destiny of British orthodontics since that date.

The membership has expanded now to over 600 and still includes a high proportion of general practitioners whose interest in the subject is essentially practical. In addition to regular monthly meetings during the autumn and winter sessions, the Society holds an annual 2-day meeting, usually outside London. The Society has decided to hold this meeting in London from May 9–11 to celebrate the sixtieth anniversary of its foundation. At this the members will be invited not only to look back over 60 years of progress but also to look forward at some of the most recent research projects for which a special session is reserved. There is no doubt that the enthusiasm with which it was launched 60 years ago remains undiminished.

STUDY AND PRACTICE

J. S. BERESFORD, B.D.S., F.D.S., F.A.C.D.S., D.Orth. R.C.S.
Consultant Dental Surgeon, The London Hospital

THE name of our Society for the Study of Orthodontics has often received comment. Membership is made up not only of specialists, who are in the minority, but also of general practitioners, administrators, and teachers. Collectively we are students of orthodontics.

The University of London offers a choice of 281 subjects for study for degrees and diplomas, and there are, of course, many studies outside university curricula to claim men's interest and energy. Anthropology, literature, human growth and development, comparative dental anatomy, are examples of subjects which might be studied for their own sake; for the inherent interest and pleasure which the study yields. Not so the art and science of restoring teeth, or of moving teeth. Doubtless orthodontists find orthodontics interesting, but I cannot imagine anyone studying the subject other than as an applied science. Not all who undertake research related to orthodontics are themselves clinical orthodontists, but they do aim to produce something relevant to clinical problems. If there were no clinical orthodontics, or clinical dentistry, there would be no point in studying orthodontics or dentistry. The dental academics, research workers, and teachers, exist only to serve the clinicians. Without the latter the former would be redundant.

Clinical know-how and applied skill have advanced to a stage beyond which further progress would seem most unlikely if it is to be based only on experience, judgement, or intuition. Contemporary research calls for a kind of scientific training which in the past has not been received by many clinicians. Epidemiological studies may be made by clinicians or by observers who often do not need to be skilled clinicians. The clinician may observe accurately and record data, but for the analysis of that data he must seek help from other professionals, such as mathematicians. For the great part, in orthodontics, as in medicine generally, the discovery of new knowledge depends upon the application of sophisticated research techniques by workers who have enjoyed a special scientific training additional to, or instead of, clinical training and experience. For real progress in dentistry the clinician is, in fact, dependent on the academician.

TEACHING

It would be agreeable to think that most men could combine in themselves both functions, the clinical and the academic. I would urge any young dental surgeon or orthodontist intent upon a successful clinical career to maintain an active interest in research and in academic dentistry as long as he could. Personally, it becomes more difficult every year to try to be a good specialist in private practice, a good hospital consultant, and a good teacher.

Many of us, if we wish to excel in one field must sooner or later withdraw from the others. Nevertheless, for a clinician there is nothing else quite like teaching for getting the knowledge, beliefs, and facts sorted out in one's mind. A period devoted to part-time teaching must be invaluable experience to any clinician.

The rub is that teaching, in the light of a university discipline, demands research work. The full-time teacher accordingly divides his week into teaching sessions, research sessions, and also clinical sessions so as not to lose his clinical expertise. Teaching, if properly done, is exhausting. It consumes mental energy. However, in a properly organized teaching department it is not easy to escape without carrying one's share of the burden. Clinical work also consumes nervous energy, but it can often be escaped. Research work is likely to become the primary interest of those who combine training, a high I.Q., and a university appointment. These people will eventually seek to spend more time in research and less in clinical work. Similarly placed, which of us would not do the same? Research work will advance the full-time teacher in his subject, indeed in his profession.

It could be argued that the part-time teacher also divides his time into teaching and research sessions in the dental school, and clinical sessions in his own practice. It does not seem to me that a man can do effective research work, year in year out, unless he devotes a minimum of four sessions weekly to it. Would a dental school employing a part-time teacher, for, say, eight sessions weekly allow him four of those sessions for research? I greatly doubt it, but even if it were so that would leave only three sessions, assuming he worked Saturday mornings, for clinical

Presidential Address presented at the meeting held on 9 October, 1967, and in a shortened form in Glasgow on 27 October, 1967.

work (in his private practice). Three sessions are too few for an orthodontist or a general dental practitioner to provide the availability and the care which are due to the patients in an established practice. Ignoring the question of the desirability of part-timers, it is clear that the man devoting four or five sessions to his dental school appointment is at a disadvantage as a teacher compared with the full-timer, because he cannot find anything like the same number of hours weekly, or yearly, for research. As regards a teaching career, a full-time man is bound to advance faster. The part-timer, unless he is a man of very exceptional talents, must recognize this together with the fact that his is perhaps a different career.

DEANS OF DENTAL SCHOOLS

Another activity, much observed in dental schools, is administration. More than twenty years ago Mrs. Lillian Lindsay observed to me that one of the difficulties of the British dental schools was that the professors were the deans. Of necessity this is likely to be so for some time. Men of proven ability are needed in those positions and much of the advancement of the profession depends not only on how they administer their schools but upon the impression they make on the members of other institutions and the leaders of other faculties. More now than a few years ago our schools contain, at senior lecturer level, a body of highly-qualified young men and women with personalities and experience to fit them for the office of dean. In at least some schools let us try appointing one of these as dean and then, in not too many years, return him to his department to continue with his academic career. This career will have been interrupted, but it need not be destroyed, and that man's skill, or that woman's skill, as a research worker and teacher will not be lost to the profession.

THE DENTAL QUALIFICATION

Before the science and art of dental surgery can be studied at graduate level, or practised, it is necessary to qualify. The young man or woman who, after a very long course, obtains a bachelor's degree, may soon wonder if he has been deceived. In any other faculty the graduate with his first degree may continue to positions of administrative or senior teaching responsibility in any aspect of his chosen subject. He must collect, as he ascends the ladder, higher degrees and acquire research training. The Bachelor of Dental Surgery must not only do all this but must also return to square one and complete a second undergraduate course leading to the M.B. To neglect this step is to find the way to the top in administration, and in teaching, blocked by doubly-qualified colleagues. Can one honestly encourage schoolboys and schoolgirls who possess the potential to become leaders in whatever profession they choose, to enter our dental schools?

The specialty of oral surgery merits a digression. That training and experience in this field must count more than qualifications is perhaps beyond argument. It is at least arguable that the present M.B., Ch.B., course includes much that young doctors and dentists could do without. Why, therefore, ask for doubly-qualified oral surgeons? The answer is one of supply and demand in a highly-developed and still developing society. If you had to submit to an operation upon your face or jaw, or if you had to choose an oral surgeon for a senior appointment, would you not prefer the man who had a general surgical background in addition to his training and experience at an oro-surgical or maxillofacial centre? Such men exist, and more are being trained. The M.B. is the pre-requisite to the general surgical training, so the potential oral surgeons can join the potential teachers and administrators in the preceding paragraph.

Students are admitted to university dental schools on the basis of personality, interests, and background as revealed at interview, 'A' level passes in specific subjects, and perhaps a schoolmaster's report. Even if it were possible by some process of further selection, to separate potential research workers, surgeons, general practitioners, and so on, it would seem highly undesirable to do so at matriculation level. The more there is in common among the different kinds of registered dental practitioner, the stronger will be the profession and the better will it serve the community.

To add a greater part of the B.D.S. course to the present M.B., Ch.B., course is a cumbersome solution to the problem of dental education. The basic medical sciences degree has much to commend it, especially for teachers and research workers, but by definition lacks a clinical element.

Rather make the M.B., Ch.B., course shorter in both clinical and preclinical aspects, and require medical and dental students to pursue one course to their first degree (which might still be called the M.B., Ch.B.). Then let them divide among the departments of medicine, surgery, dental surgery, and as many specialities as you like.

If such a scheme is evolved, it is likely to require some revision of the requirements for medical registration.

In order to register, most of the young doctors might take a further degree or diploma in general practice, but a number would follow other paths leading to specialization in medicine or surgery. At the same time, the dentals would take a mainly clinical and very thorough course for their B.D.S. Presumably F.R.C.S. candidates will always make a profound study of anatomy, but I think that the future general medical and

dental practitioners will learn regional anatomy in much less detail than at present. They will have plenty of other things to learn, ranging from more biochemistry to statistical method and psychosocial humanity (Walsh, 1966).

With all this, it must be insisted that the dental surgeon remain a good, I would like to think a superb, technologist.

TECHNOLOGY

Craddock (1957) points out that, ' the business of a university is not merely to teach this or that, but to train minds; and that a technological subject approached in the right way is almost as good a medium for this purpose as mathematics or modern languages. In a university a young man finds the inspiration that is kindled by contact with brilliant minds. Whatever his subject, he finds it handled with that strict intellectual integrity, that searching enquiry and criticism, and that contagious enthusiasm which shape one for life.'

Craddock also comments on the dignity of craftsmanship and the personal satisfaction which follows first class technical achievement in dentistry. Far from denigrating the craft content of dentistry he believes that it lends to the subject a discipline of peculiar value. It is the discipline of excellence.

Today, dental practice is an applied science as well as an art, and it has a substantial and increasing intellectual content which rationalizes practice and reaches its purest form in research and diagnosis. Diagnosis is not a question of how to do something but of what to do. This is an intellectual, not a technical, problem. The dental surgeon must be able in answering the intellectual question, and skilled in solving the technical problems which follow.

ORTHODONTIC TRAINING

In terms of national economy, the length of the dental course, and administrative convenience, orthodontics has about the lowest priority of all the technologies in the undergraduate curriculum. To further an understanding of the function and development of the masticatory mechanism, of the environment of the dentition and its ' biomechanics ', and in co-ordinating all the subjects in the undergraduate curriculum orthodontics is surely the most important study of the senior dental student. To teach the subject in co-operation with the paedodontists, and even in the same department and in the same sessions, seems reasonable.

To detach orthodontic theory completely from practice would seem to be very poor teaching method, and the undergraduate must certainly, himself, treat a small number of patients with malocclusion. For administrative convenience he is likely to use removable appliances. If, later, in general practice, he begins to treat a number of orthodontic patients, he will doubtless seek further help from orthodontic colleagues nearby and from the regional consultant.

It should be clearly appreciated that the training of the specialist orthodontist calls for a very different set up. The young graduate, with a few years experience in other branches of dental surgery, should ideally join the orthodontic department with the greatest number of first class orthodontists on the clinic floor. The department should possess those clinical amenities which are available in every private orthodontic practice and without which hospital orthodontic practice becomes intolerable. It might possess even better physical facilities, and like all the dental school departments it should be supported by research and other academic activities. A senior orthodontic registrar may well join a small orthodontic team in a hospital, to their mutual benefit, but I would urge the beginners to start their careers in the big departments whenever they can.

Let us look now less at the study and more to the practice of dental surgery.

ORTHODONTIC PRACTICE

In this country it is rare for an orthodontist to receive a patient except by reference from a medical or a dental colleague. To be discerning in such matters is one of the duties of general practitioners. Presumably they consider the orthodontist's qualifications, experience, and hospital appointments before sending him a patient, and perhaps also his success-rate if that can be ascertained. We all have our treatment failures and sometimes the fault is not our own, but it is very unfortunate for practice building to receive two uncooperative patients in succession from one general practitioner! Some imponderables also enter into the question of referring patients, but it can safely be left with the general dental surgeons who have ample evidence to guide them without the addition of ' certification ' by an orthodontic board or by the General Dental Council. The public is not competent to judge if a man is up to standard as a dental surgeon, therefore dental registration is needed to protect the public. The dental surgeon certainly is competent to judge an orthodontist and he is in a position to protect his patient, should the need arise, from the orthodontist.

The orthodontist does not need protection from the general dental surgeon. If the dental surgeon wishes to include some orthodontics in his general practice it will make his life more interesting and he deserves all the help the orthodontist can give him. His practice will grow because the relatives of his child patients will come to him too. In about three years he will be so busy rehabilitating the dentitions of the

progenitors of the children with malocclusion that the latter will all be referred to the helpful orthodontist!

Much of the orthodontic treatment in this country is provided within the General Dental Service of the National Health Service. The extent is 100,000 courses of treatment, 60 per cent of which involve appliances, per year. I was active in that service for more than ten years and am grateful to it for the livelihood it provided.

Most of the general dental treatment in this country is also provided under the Health Scheme. It is easy to criticize the Service, but it should be remembered that its basis is taxpayers' money spent for the good of the patients. It is organized and administered by more or less democratic committees of various kinds, including parliament. Committees often take wrong decisions, and we all know that compared with private enterprise they are slow and cumbersome. They are, however, a tremendous safeguard.

THE GENERAL DENTAL SERVICE

In so far as the General Dental Service lacks a career structure or a financial award for better service it is dependent upon the dentists' sense of vocation. It behoves those who enter the Service and those who administer it to give this serious thought. Is the dentist satisfied that such a Service will sustain him, and his family, year upon year until his retirement? Is the government satisfied that the present arrangement of the General Health Service is the best?

Despite the enormous size of the Health Service some aspects of medical care are still rationed in this country. For many years at hospital I had to differentiate between degrees of need for orthodontic treatment among different patients and to try to balance the demand against the number and capabilities of those who would provide the treatment. It just did not balance and many went without. There are waiting lists for some forms of medical and surgical treatment and from time to time the newspapers remind us of the shortage of kidney machines and such apparatus.

Some aspects of the General Dental Service of the National Health Service merit comment and I need hardly say that the comments are mine and not the official opinion of this Society. It is most unfortunate that the entire structure is built upon the fable of dental fitness for all the citizens in the kingdom. The dental surgeon must not say that private treatment is better than National Health Treatment and he must choose his words with care if he would suggest to a patient that some alternative material might be provided if a fee, approved by the National Health authorities, were paid. Through trial and error most dental surgeons on Executive Council lists have learned what the Board understands by dental fitness and what standards have become recognized. The myth, however, remains that a patient can be made dentally fit in the presence of a frank Class II, division 1 malocclusion because the dental surgeon cannot or will not treat it or cannot afford to do so for the Board's fee. Am I wrong in regarding the General Dental Service as a very good service for a large part of the population up to a certain recognized standard of dental surgery, based upon the rapid relief of pain and the provision of a high standard of restorative dentistry?

When an attempt is made to introduce advanced restorative work, extensive crown and bridge work, or lengthy periodontal treatment, difficulties and dissatisfaction arise.

Certain forms of dental treatment are expensive and I understand that some Executive Councils have been urging that an adequate fee should be paid for such work. Commendable as this might be the question remains, can the Treasury afford it? If the answer is no this should be clearly stated to the population at large and all pretence abandoned. The General Dental Service in Britain is a magnificent example of social endeavour, but by pretending that it is something which it is not we can only harm socialism itself.

Throughout the country our colleagues who serve on local dental committees and on executive councils wrestle with the problems, both large and small, of the Health Service. I want to say something now about the problems of professional life from the viewpoint of individual dental surgeons.

Total satisfaction with, or through, the scale of fees is unlikely ever to come about. Unless the Minister of Health fails in his duty to the taxpayers it seems unlikely that a scale of fees acceptable to all, in every detail, will ever be offered. Nevertheless, I suggest this is not the main cause for discontent among our colleagues, some of whom are satisfied with the financial return and sense of security which the Scheme affords, and all of whom are relieved that general dental care is so readily available. From his early days as a student the dental surgeon learns that the giving of proper, dispassionate advice is a hallmark of his profession. It is when this advice is called to question by a third party that he feels offended.

But his advice must be subject to scrutiny if we are to operate a decent health service! If you were administering the Service would you give *carte blanche* to every dentist, regardless of the cost of the procedures he recommended? Submission to controls and regulations is a paradox of freedom.

Neither a recognition of this fact nor our desire to serve the community should lead us to regard such submission as the be all, and end all, of

professional life. The dental surgeon is free to work when and where he can find employment, perhaps as a university teacher, perhaps in the schools or hospital service, perhaps in practice.

In common with workers in every branch of medicine, we earn our daily bread as a consequence of the illnesses or misfortunes of others. We perform a service and we earn a living, but whether income is derived directly from the patient or indirectly from the taxpayer via the Treasury it still stems from illness or misfortune. If there were no need for doctors and dentists the Treasury would not pay the teachers nor would there be very much money for the research workers. Anyone who cannot reconcile the ideals of our profession and its humanitarianism, with the necessity of earning his living ought not to be in practice nor should he be in a salaried service.

In order to make the proper contribution of an educated professional man to the society in which we live, that is to our environment, we must earn an adequate livelihood. Even Marx (1875) said, ' From each according to his ability, to each according to his needs '.

How is a General Service practitioner to reconcile his humanitarianism with the need to earn his living and at the same time to preserve a sense of professional freedom and dignity?

AN ATTITUDE OF MIND

There are districts where the dental surgeon is unlikely to see a private patient from one year's end to the next. Even he, in my opinion, should let it be known, in a perfectly kindly way, that an individual who comes to him is his National Health patient only between the initial signing of a new National Health form and the ' signing off ' of the same form at the completion of treatment. If a dental surgeon wishes his judgement to be respected he should not let his patients assume that he is in the same category as a civil service junior clerk. This does not mean a political tirade at the beginning of every appointment, but only the cultivation of an atmosphere in which the patient requiring National Health treatment understands that he receives it only when the dental surgeon is agreeable to accept him on those terms.

If you practise in a district where you may reasonably expect to receive a small number of private patients I would strongly urge you, from the earliest days of establishing the practice to set aside some time, even half a day a week, as time when you see your private patients. A definite time must be set aside so that your secretary can say that on Friday mornings for example Mr. So and So sees his private patients.

Apart from emergencies your National Health Service practice would be just as much closed on Friday mornings as on Sunday afternoons. Otherwise the situation might arise where a patient could be told that there was a long wait for a National Health appointment but a private patient could be fitted in somewhere. This sort of thing would go down very badly, and however aggrieved the dental surgeon might feel because of certain National Health regulations it would reveal him in a very poor light. If you conduct both private and National Health practice it is much better to set aside certain days or half days rather than to say that you will see private patients only during the busiest and most popular hours and National Health at the other times. Any such policy would appear to be quite unfair. You must also be prepared to cope with emergencies as they arise and to see patients who are in pain with the minimum of delay. It is the professional man's responsibility, privilege if you like, to arrange his appointment book, and indeed his whole life, so that he may do this. And it can be done without placing yourself at the beck-and-call of every neurotic individual in the neighbourhood.

The most important service which we render our patients is the giving of advice, based of course upon clinical, radiological, etc., examination, and private patients are regularly charged for this advice. The best advice is sometimes to do nothing, and this should be thought very good value. With certain exceptions, which are irrelevant to this argument, it is contrary to the spirit and the letter of the regulations to charge a fee to a Health Service patient. It is legal to examine a patient before saying whether you will accept him ' under the Scheme ' but quite unethical to charge a fee for an examination conducted in such circumstances. Legally the patient becomes a Health Service patient when the dental surgeon has by word or action indicated that he agrees to accept the patient under the Service. Acceptance does not depend upon the Health Service estimate form being signed. The dental surgeon will have guarded against any impression of verbal acceptance by explaining the purpose of his initial examination, if he wishes to conduct this examination before deciding whether or not to accept the patient under the Service. Nevertheless, it is an examination in contemplation of possible Health Service treatment, and common decency demands that it be conducted according to the spirit of the regulations.

Part-time staff can be faced with a comparable situation in the matter of hospital waiting lists. To accept a fee for a private consultation and then to use one's influence or authority to obtain for that patient priority in a hospital waiting list would be surely unethical.

A private practice is conducted in one's own consulting rooms as distinct from hospital or medical centre practice. In a private practice

there may be all National Health or all fee-paying patients, or some of each. For the rest of this paper the term private practice will be used in its restricted sense, applied only to the practice, or that part of a practice, made up of private patients.

PRIVATE MEDICINE OR STATE MEDICINE

The question that now arises is the propriety of private practice existing alongside state practice. It has been argued (Wade, 1966), that private practice is so much the antithesis of National Health practice that the two are incompatible and that ' the success of one is bound to involve the failure of the other '. The argument, which assumes competition for scarce resources coupled with a shortage of Health Service money, does not seem to me to have been satisfactorily worked out.

By regulating the supply of resources, such as new hospitals and medical schools, government can control the degree of scarcity and by legislation can make some facilities, for example, prescribed medicines, more readily available to the National Health Service than to private practices. This seems valid in the interest of the community, but the regulations must not prohibit private practice nor impose such great handicaps upon it as would add up in effect to prohibition.

It is hardly conceivable that the state should make direct grants to assist private practice. Indirectly, the private practitioner does receive various forms of state aid, beginning with his education. It is a generally accepted function of the comparatively highly-developed countries to provide further education at reduced cost, or at no cost at all, without asking for service in return. We believe that this enriches the community life, and in a free world we do not count the export of a proportion of highly-trained people as a loss. Most research work is now financed by the state, and even that financed by ' industry ' is likely to depend to some extent upon the use of state-owned buildings and help from state employed personnel. The fruits of research and the benefits of specialist laboratories and expensive hospital equipment are available, directly or indirectly, to private practitioners. Although, in theory, socialized medicine could manage very well without private practitioners they do at present make a considerable contribution to medical skill within, and to the administration of, the National Health Hospitals.

Certain advanced techniques, at least in conservative dentistry and in orthodontics, are much more practised in private than in hospitals. This is partly because the hospitals cannot or will not pay the technicians and the lay staff on whom the dental surgeon depends. Here is a form of competition for scarce resources, personified by skilled technicians and experienced chairside attendants, but in the absence of private practice these people would be harder to come by. Many would simply take up other work. Because private practice exists there are more skilled ancillary staff about; and because salary is not always the primary consideration when seeking employment there is some exchange of such personnel between state and private employment, to their mutual benefit.

The environment of a university dental school is conducive to research and to the development of new materials and advanced techniques. These techniques are perpetuated in practices rather than in universities or hospitals, and at present in private rather than in National Health practices.

To make every form of advanced dentistry available to all through the Health Service, with or without ancillaries, will cost money. Does socialist theory demand that an adequate sum be raised by taxation? Should the members of the community be allowed a free choice between spending their money on more entertainment, clothes, cars, or on more dental care?

Private practice offers a more satisfying way of serving the community for those dental surgeons who do not see themselves as employees of the state in one guise or another. Private practice offers the state competition.

It is thoroughly desirable that methods of practice be allowed to vary against one another to reflect different interpretations of what is best for the patient. To prevent such differences being reflected in varying kinds of practice would be to deny the Health Service, and perhaps the whole of medicine, a considerable stimulus to its own advance.

The argument can be taken one step further remembering that in a hypothetically very wealthy nation a National Health Service might not be needed. The stimulus of competition works both ways, and it should not be assumed that in the absence of a National Health Service, private practices would be better, or even that private practitioners would be better off. In my opinion what is best in private practice is likely to survive against, and even be stimulated by, the competition of a committee organized National Health Service.

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DISCUSSION

In London:

Mr. L. B. Whittaker said the President's remarks would be of interest to a young dental student and wondered if the President would care to suggest where the student could, with greatest advantage, study his orthodontics.

Mr. F. Allan expressed dissatisfaction with the orthodontic departments of dental hospitals. They had been unwilling to help him with his problems, and he felt that there was inadequate provision of postgraduate instruction.

Mr. J. H. Hovell thought that the future of undergraduate training was the future of dental surgery in this country. In fact, if undergraduate training was adequate, there should be no need for people to take a medical qualification, in oral surgery, orthodontics, or anything else. He thought that the combined course suggested by the President was the answer to this. Where it broke off, how it broke off, how the course was streamed afterwards, was a matter which needed to be gone into very thoroughly.

He thought that a Commission on dental education was needed in this country. There had been one on Medical Education which had not yet reported. The dental profession had asked for dentistry to be included, but was turned down. As a profession he thought they should ask again. Students were being trained in an extremely unsatisfactory manner at the moment.

The President, replying to Mr. Whittaker, said that he did not really know the answer. He just did what Mr. Berman and Mr. Rose told him. At the London Hospital, students received an introduction in their third year. This was concentrated in the fourth year and they did their best to hammer it home even further in the fifth year.

His conscience was clear with Mr. Allan. He had been privileged to see one of Mr. Allan's ideas. Mr. Allan did not know this until now. It was a long time ago, so he doubted whether Mr. Allan could identify it. He thought it was very good and quietly put it to use in his own practice.

With regard to teaching cephalometrics, they did their best. He had had a class at 9 a.m. that very day on the subject.

He was sure Mr. Hovell was right. There was need for a Commission on dental education. The difficulty, of course, was that it was one thing to work these ideas out and quite another to put them into practice. One could dash up to a professor of physiology and say, ' I want three more lectures for students this year '. The professor would say, ' Measure my lab., count the seats and the number of junior lecturers I have. It just cannot be done '. It was a slow business.

In Glasgow:

Professor T. C. White, opening the discussion, began by welcoming the members to the third oldest medical college in the British Isles. The Royal College of Physicians and Surgeons of Glasgow had a long affinity with orthodontics which had been particularly strong since 1949, when it set up a diploma in the subject.

He found himself in complete agreement with much that the President had said and slightly embarrassed at having to disagree with any of it, but there were one or two points he would like to mention. The President stressed the necessity for research. Professor White thought we had to find a balance. Research had got to be useful and there was a tendency for the young man, whose natural ambition was to get on, to try to replace his lack of years and clinical experience by reading the papers of research workers. Some were excellent; some not so good. He felt we must not go overboard for research.

Turning to the M.B. as part of training, he wondered if it was really necessary for an orthodontist. If he was going to have his mandible removed, he would prefer a man to have an F.R.C.S., but he might have more clinical experience in orthodontics if he had not taken an M.B. Although he had a medical qualification himself, he was not afraid to call himself a dentist first and foremost. He agreed that there was a trend towards the need for a medical degree and he felt this was most disturbing. They must await the report of the Commission on Medical Education whether any revolutionary suggestions would be made which would reflect on the training of the young dentist.

Dr. G. B. Hopkin agreed with most of Professor White's remarks, but he was a little disturbed by the suggestion that research was useless unless it was clinically directed. There was an increasing tendency in this country for politicians to seek more and more ' cost effectiveness '. He agreed that one had to keep a sense of balance, but he thought it was regrettable if everything done at a university had to be measured in cash benefit to the community.

The President, replying, said he agreed with much of what Professor White and Dr. Hopkin had said, and he was reminded of a Scottish Professor in New Zealand who frequently quoted Faraday's remark ' What is the use of a new-born babe?'

USE OF OBTURATORS IN THE EARLY MANAGEMENT OF A CASE OF PIERRE ROBIN SYNDROME (PIELOU'S METHOD)

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THE Pierre Robin syndrome classically embraces the combination of micrognathia, glossoptosis, and cleft palate. The cleft is usually incomplete and not infrequently involves the soft palate only.

The initial problem in treatment of these cases is often that of maintaining an airway, for, owing to the defective mandibular development, there is inadequate anterior support for the tongue which falls back, obstructing the pharynx. The inability to protrude the tongue also makes feeding difficult—apart from the problems associated with the cleft palate, if present.

Hitherto surgical methods have been used to maintain an airway, or at least a suture has been passed through the tongue to hold it forwards—the free end being attached to some external object. However, Pielou (1967) has recently described an obturator to hold the tongue forward by means of a flange extending distally and downwards, behind the tongue, and this report is of a case treated by this method. As it proved to be an apparently life-saving procedure it is felt that the more widely it becomes known the better.

Fig. 1 illustrates the mode of action of the obturator, which is remarkably well tolerated by the patient, and *Fig.* 2 shows the obturator with its distal flange, the degree of curvature of which approximates to that of an everted thumb. There are two ' wings ' extending back outside the cheeks to facilitate the appliance being held in place by tapes. As Pielou points out: once the infant accommodates to the forward position of the tongue, bottle feeding becomes feasible, as the obturator occludes the cleft at the same time.

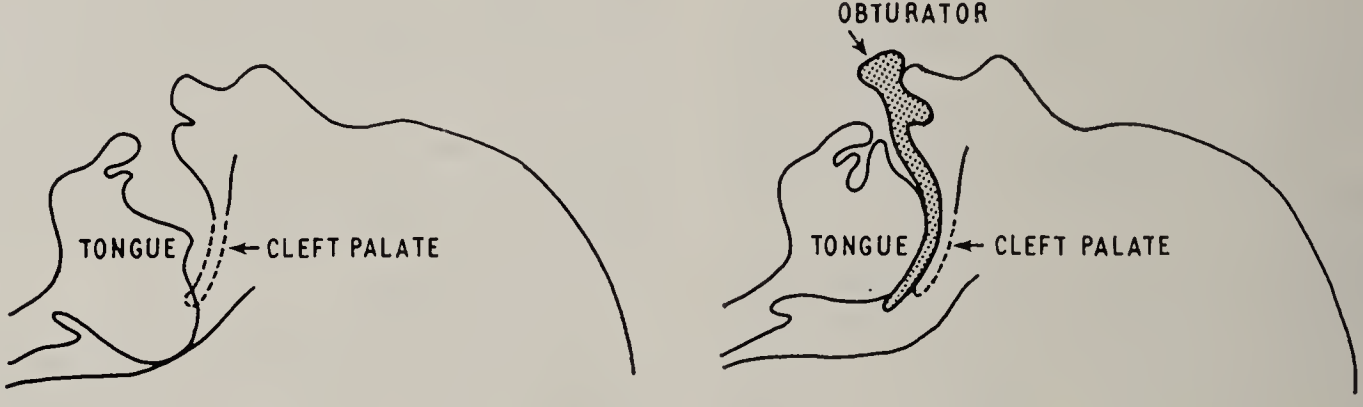

Fig. 1.—Diagram to show method by which the obturator holds the tongue forward. (*After Pielou.*)

CASE HISTORY

The boy was small at birth owing to a placental deficiency and weighed only 4 lb. 1 oz., although the pregnancy went to full-term.

Although the micrognathia was severe, no specific therapy was necessary until the fifth day of life, when respiration became very rapid and laboured. A frame (Bromley and Burston, 1966) was constructed which allowed the infant to lie face-downwards, keeping the tongue forward and relieving the upper airway obstruction. This worked well during the following

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12 days, but the infant then became intolerant of it and on the nineteenth day of life it was necessary to remove the child from the frame and put a suture through his tongue. On the end of the suture was placed a weight (e.g., haemostat) to hold the tongue forward. Dramatic relief was obtained as the child's cyanosis vanished and his air entry became reasonable.

Repeated replacement of tongue sutures was necessary because the constant traction tore the suture

Fig. 2.—Showing the obturator from its palatal surface.

Fig. 4.—Lateral view of patient to attempt to show degree of micrognathia.

out of the tongue. Invariably, during the interval when no suture was present the child became cyanotic and went into heart failure. The sutures were replaced on approximately 10 different occasions, and at one stage closed cardiac massage and mouth-to-mouth resuscitation were necessary. Not unnaturally, the general condition of the child was not improving at all during this period.

It was then decided to attempt the use of an obturator of the type described by Pielou in an effort to keep the tongue forward by less traumatic means. The initial two obturators fitted were not well tolerated, but a smaller, thinner one was immediately acceptable from the time of fitting this latter appliance until discharge at the age of 99 days; the child had no difficulties, and during the last month in hospital the obturator was necessary only for feeding purposes.

Fig. 3 shows the obturator at the time of its first fitting. The tongue suture is still in place and the infant is wearing mittens to avoid interference with this or the obturator. *Figs.* 4 and 5, at 48 days and 99 days respectively, are an attempt to show the degree of mandibular development which has already taken place.

Fig. 3.—Showing the obturator at the time of first fitting. Note tongue suture present.

Fig. 5.—Aged 99 days showing definite signs of rapid mandibular development.

Just prior to discharge a fresh obturator was made without flanges to facilitate bottle feeding. This he now uses without difficulty; his weight at discharge was 10 lb. and there is further considerable mandibular development.

DISCUSSION

It is sometimes claimed that if such cases are adequately nursed by specially trained nursing staff, no surgical or other intervention would prove necessary. However, it is freely admitted that such nursing would involve full-time bedside attention. This appliance, therefore, once

accepted, would remove the danger of a sudden respiratory emergency, and consequently lessen the demand on nursing staff.

The prognosis for cases of Pierre Robin syndrome is generally good provided the initial difficulties can be overcome. Mandibular growth is then usually rapid in the first three or four months and sufficient to ensure that no further respiratory emergencies will occur.

The belief is held in some quarters that the way the tongue drops back in the mouth is due to lack of development of the oral reflexes, not to the micrognathia. Therefore, it is when these reflexes are fully established that the period of danger is past, and is not dependent on mandibular growth.

Be that as it may, whatever the cause, in this case the tongue was adequately held forward by this appliance without recourse to any further surgical procedure and if we had known of the existence of this appliance earlier, severe trauma to the tongue might have been avoided.

As mentioned at the beginning, details of this appliance were initially described in an article by Peilou, and as no account has yet reached the dental literature* the main purpose in presenting this paper is to bring to the notice of members the nature of the appliance, in case they should be faced with a similar problem. It is thereby hoped that a knowledge of its design, if not actually saving a child's life, may at least help to avoid unnecessary trauma, and reduce the difficulties of nursing.

Acknowledgements

Our thanks are due to Dr. Simpkiss for permission to publish details of the case, to Mr. Hooper for his interest and considerable help and for taking the photographs; also to Mr. R. Cunningham, the technician who actually made the appliance. We would also like to thank Mr. W. D. Pielou for permission to reproduce *Fig.* 1.

* This article was accepted for publication before the recent article by W. D. Pielou and A. Allen (*Dent. Practnr dent. Rec.*, 1968, **18**, 169) was published.

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DISCUSSION

Mr. C. P. Adams, speaking as a colleague of Mr. Pielou's, said Mr. Pielou had treated about eleven cases and had already noted some differences in response to treatment which were significant. He had observed that if the infant was left for a time without treatment and became adapted to its environment and disability, there was resistance to accepting the appliance. The longer the infant was without an appliance the more difficult it was to settle down with the appliance when provided, whereas an infant which received an appliance within a day accepted it within a minute or two. Mr. Pielou noticed that one case in which the appliance was refused was in an infant who was exceedingly active and seemed to be able to manage in spite of its disability without any assistance; this may have been a case in which the child overcame its physical defect by active, instinctive effort.

With regard to the way in which the appliance worked, Mr. Pielou is of the opinion that a great part of its action is in stimulating tongue activity as much as, or even more than, in holding the tongue forward, and that the establishment of function is an important factor in improvement in these cases; children who receive the appliance early begin normal sucking activity at once.

THE STABILITY OF THE LOWER LABIAL SEGMENT

A CEPHALOMETRIC SURVEY

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MUCH of orthodontic treatment is concerned with the correction of the labiolingual position of the incisor teeth. The stable position of the lower incisors, and the extent to which they may be moved anteroposteriorly, is central to such a consideration, since it affects also the stable position of the corresponding upper teeth. Most orthodontists hold strong views on this subject, although there is no unanimity of opinion, and experimental evidence is minimal. Litowitz (1948) examined the problem in an essentially qualitative investigation, and came to the conclusion that any great amount of labial or lingual movement was rather likely to relapse. In a number of recent papers (Mills, 1964, 1966a, 1967) I have attempted to shed some light on this problem, and the purpose of the present paper is to correlate the results of these previous studies and, with the aid of additional evidence, to draw some general conclusions.

The investigation is based on the study of lateral skull radiographs taken from the files of the Eastman Dental Hospital, London. The only criterion was that the radiographs should be of adequate quality, and include in each case one taken before the beginning of treatment and one at least 12 months after all appliances (including any retention appliances) were removed.

Table I.—DETAILS OF THE GROUPS INVOLVED

		1	2	3	4	5	6
		CONTROL GROUP A	CONTROL GROUP B	$\overline{4\|4}$ EXTRACTED	LOWER INCISORS PROCLINED	LOWER INCISORS RETROCLINED	CLASS III CASES
No. in group		23	24	37	46	22	18
Age first radiograph (years)	Mean	8·99	13·89	11·11	11·15	11·77	11·38
	S.D.	0·70	0·76	1·41	2·44	1·90	2·76
Age final radiograph (years)	Mean	13·89	18·88	16·15	18·04	18·26	17·19
	S.D.	0·76	0·79	1·72	2·87	2·47	2·24
Under observation (years)	Mean	4·89	5·00	5·03	6.87	6·50	5·81
	S.D.	0·23	0·16	1·70	1·96	2·32	2·29
Out of retention (years)	Mean			2·64*	3·10	2·75	2·59
	S.D.			1·56	2·51	1·82	1·86

*Of 34 cases. In 3 cases no appliances were worn in either arch.

They comprise the following groups:—

1. Two groups of completely unselected children who attended the Eastman Dental Hospital for routine dental care, and who did not receive orthodontic treatment. One group, of 23 individuals, was first radiographed at a mean age of

Presented at the meeting held on 13 November, 1967

9 years and again at a mean age of 14 years. The other, of 24 individuals, was radiographed at 14 and 19 years. Thirteen children are common to the two groups. These will be referred to as the control groups.

2. A group of 37 individuals in whom $\overline{4|4}$ had been extracted as part of orthodontic treatment, but in whom no appliances were worn in the lower dental arch. Many of these children had worn upper appliances and some of these carried a bite plane on which the lower incisors impinged. In no case, however, had an appliance

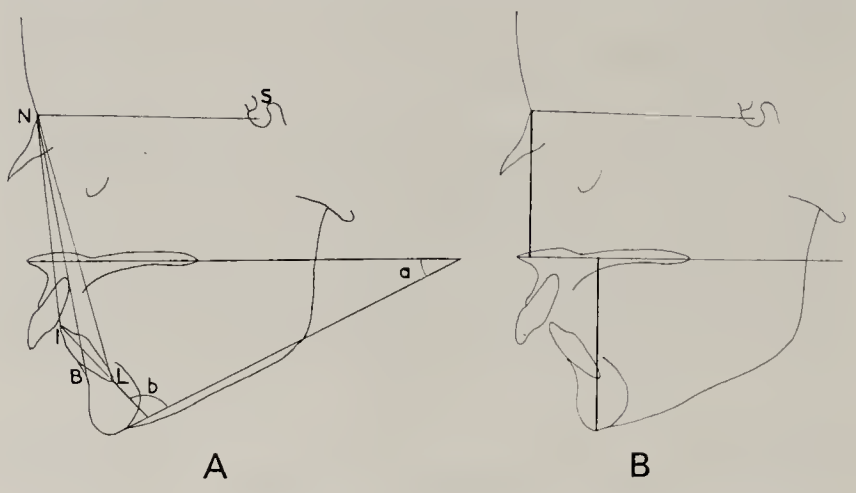

Fig. 1.—Diagrams showing A, Points used in the angular measurements. B, The two linear measurements (the thick vertical lines).

of any sort been worn for at least 12 months. This was similar to the group used by Mills (1964), but in the interests of uniformity the radiographs were traced afresh by Miss G. T. D. Pickard, who traced all the remaining radiographs in the study. A few further cases were added, while later radiographs were obtained for the children in the 1964 study where possible.

3. A group of 46 children in whom the lower incisors had been proclined at least 7°; that is, the angle between the lower border of the mandible and the long axis of the lower incisor was at least 7° greater at some stage during treatment —as measured in a lateral radiograph—than it had been at the beginning of treatment. This sample was taken from the cases reported in the 1966a study.

4. A group of 22 children in whom the lower incisors had been retroclined by at least 7°. This was the sample described by Mills (1967). All the cases had a Class I or Class II incisor relation, since I felt that Class III cases, where the incisor relation was changed during treatment, might present rather different features. To confirm this, a sample of 18 Class III cases, in whom the lower incisors had also been retroclined at least 7°, was studied separately.

The details of these samples are shown in *Table I.* Each child had a number of radiographs, taken at significant stages in treatment, and all these radiographs were traced. The accuracy of the technique has been assessed previously by double determination (Mills, 1966a). In each case the most labially placed incisor was traced, since it was found that this was the only one which could be traced with any accuracy. The points used for the 7 angular and 2 linear measurements are shown in *Fig.* 1, and will be detailed as they arise.

RESULTS

Skeletal Pattern

It is still believed in some quarters that the tooth movements detailed above, and especially

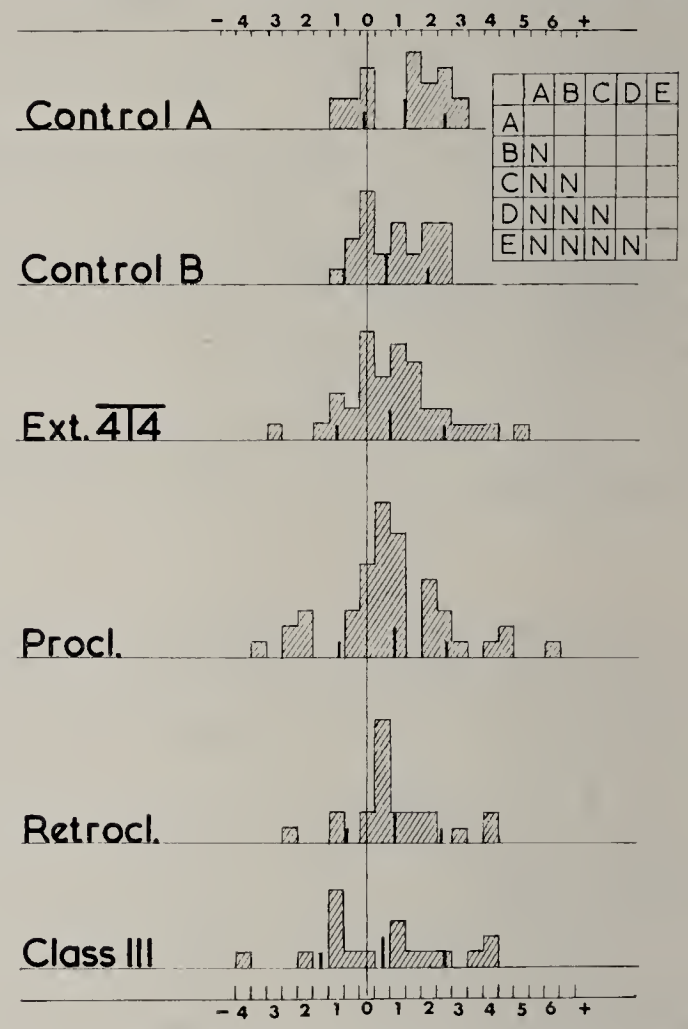

Fig. 2.—Series of histograms showing the changes in the angle SNB in the two control groups, following extraction of lower first premolars, following proclination of lower incisors, following retroclination in Class I and II cases, and finally in Class III cases. The longest of the thick lines shows the mean change, and the two shorter lines the width of one standard deviation. The *inset* shows the significance or otherwise of the difference between the two groups. For details *see text.*

the extraction of teeth, may affect the growth of the jaws, and thus the anteroposterior position of the anterior end of the dental base. Jacobs (1965) compared 10 cases treated by means of serial extractions with a control group of similar size, and found that the experimental group had the anterior dental base more posteriorly placed, at the end of treatment, than did the control. Ringenberg (1967), working on a larger group, apparently in the same hospital, was unable to confirm his findings.

In the present case I decided to find the effect of the various tooth movements on the angle

SNB (*Fig.* 1 A). This is a widely used angle, which reflects fairly accurately the position of the anterior dental base. Only if this angle appeared to show any response to the tooth movements would the matter be investigated further.

The histograms which form *Fig.* 2 show the changes which take place in the angle SNB during the periods of observation, for the individual cases. In each case, the mean change is shown by the longest thick line, while the shorter thick lines indicate the width of one standard deviation. The detailed results are shown in *Table II*, while *Fig.* 2 (*inset*) shows in diagrammatic form the results of tests of significance, using Student's '*t*' test, between the various groups.

In this, and similar subsequent diagrams, the various groups are represented by capital letters at the top of each column and the left of each row, as follows: A, The younger control group. B, The older control group. C, Extraction of first premolars. D, Proclination of lower incisors. E, Retroclination of lower incisors. The significance of correlation between the change in two groups is shown by a letter where the appropriate column and row intersect, N indicating that the correlation is not significant at the 0·05 level, P that it is possibly significant; between the 0·05 and 0·01 levels, and S that it is significant; the 0·01 level or better.

In this diagram the Class III group was excluded, being too small for the purpose. There is no significant difference between any two groups, and indeed the uniformity of response between the experimental groups is striking. It seems extremely improbable that the extraction of lower first premolars or any other procedure involved has any effect on the anteroposterior skeletal relationship.

It might be claimed that changes in the position of anterior teeth, and expecially the extractions, could be responsible for 'opening' or 'closing' the bite, by changing the distance vertically between maxillary and mandibular dental bases. Two methods were used to investigate such a possible change.

The first was by measuring the changes which take place in the angle between the maxillary and mandibular planes, the angle a in *Fig.* 1 A. These are shown in *Fig.* 3 and *Table II*. It will be seen in *Fig.* 3 (*inset*) that the only definitely significant difference is between the two control groups. This is the result of an age difference, especially as the younger control group and all the experimental groups contain the period of

Fig. 3.—Series of histograms showing the changes in the maxillomandibular planes angles in the groups detailed in *Fig.* 2. The *inset* shows the significance or otherwise of differences between groups.

Table II.—Changes in the Skeletal Pattern during the Period of Observation

	SNB		Max./Mand. Angle		Facial Proportions	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Control group A	+1·20	1·29	−1·76	1·62	+0·06	1·03
Control group B	+0·60	1·39	−0·48	1·73	+0·59	0·97
$\overline{4\|4}$ extracted	+0·85	1·56	−1·86	2·70	+0·23	0·94
Lower incisors proclined	+0·83	1·72	−1·50	2·50	+0·63	1·53
Lower incisors retroclined	+0·89	1·51	−2·18	3·39	+0·27	1·25
Class III group	+0·50	2·00	−1·17	1·98	+0·94	1·76

puberty, which is virtually ended when the older control group commences. There is no significant difference between any of the experimental groups.

The second method of investigating the change of vertical skeletal relationship was by measurement, as shown in *Fig.* 1 B. A perpendicular was drawn from the nasion to the maxillary plane,

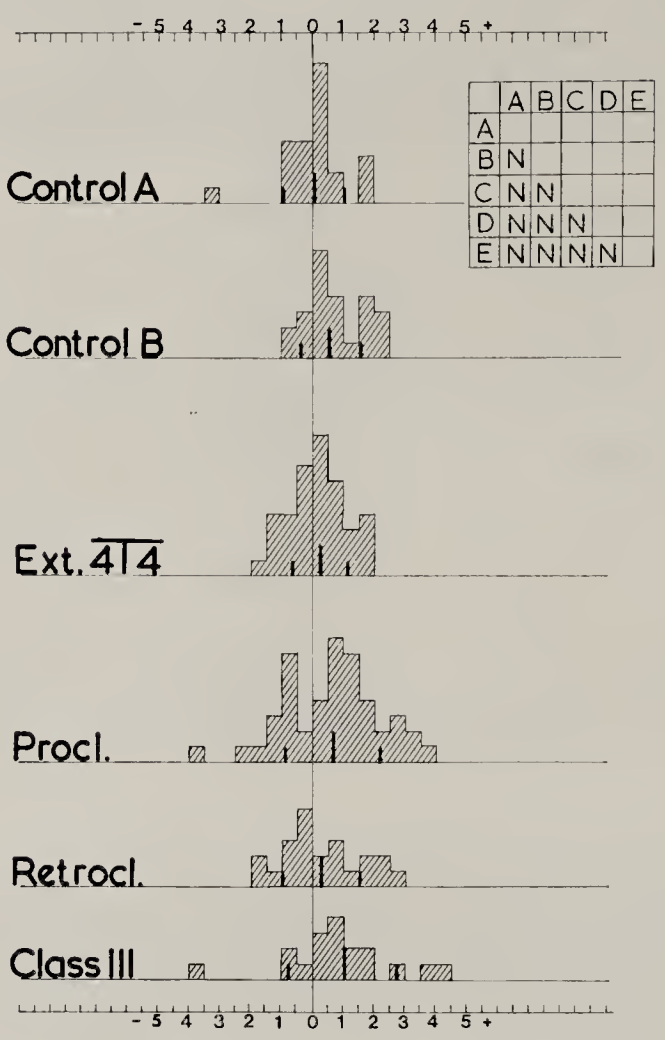

Fig. 4.—Series of histograms showing the changes in facial proportions in the groups detailed in *Fig.* 2. The *inset* shows the significance or otherwise of differences between groups.

and a second perpendicular from menton to the maxillary plane. The lengths of these were measured, and the latter expressed as a percentage of the sum of the two measurements; that is the lower facial height as a percentage of the total facial height. This remains, in average terms, very constant between the groups (*Fig.* 4), and it will be seen in *Fig.* 4 (*inset*) that there is no significant difference between any of them.

It would appear, therefore, that none of the tooth movements described has any effect on the vertical relationship of the dental bases. It may be that changes in the incisor angulation to be described later would have a very slight effect on the incisor overbite. No attempt was made to assess this, since much greater, but variable changes were produced in the incisor overbite by deliberate appliance therapy in many of these cases.

Changes of Incisor Position

The most usual method of assessing anteroposterior change in position of the lower incisors is from the angle between the long axis of the lower incisor and the mandibular plane; the angle b in *Fig.* 1 A. Ricketts (1964) and I have both drawn attention to the unsatisfactory nature of such a measurement, and this is well illustrated here (*Fig.* 5). In all the groups the change in this angle shows a wide variation. It can be affected by movement of both the incisal edge and the root apex, and also, indirectly, by changes at either end of the mandibular plane. In addition, it is basically a difficult angle to measure accurately; we found that we were within 2·5° of the correct measurement in only 66 per cent of cases (Mills, 1966a).

Nevertheless, the different types of treatment produced long-term results which were significantly different from each other and from the control groups (*Fig.* 5, *inset*). Proclination of the lower incisors caused them to end up about $6\frac{1}{2}°$ more proclined than they would otherwise have been; extraction of lower premolars left them

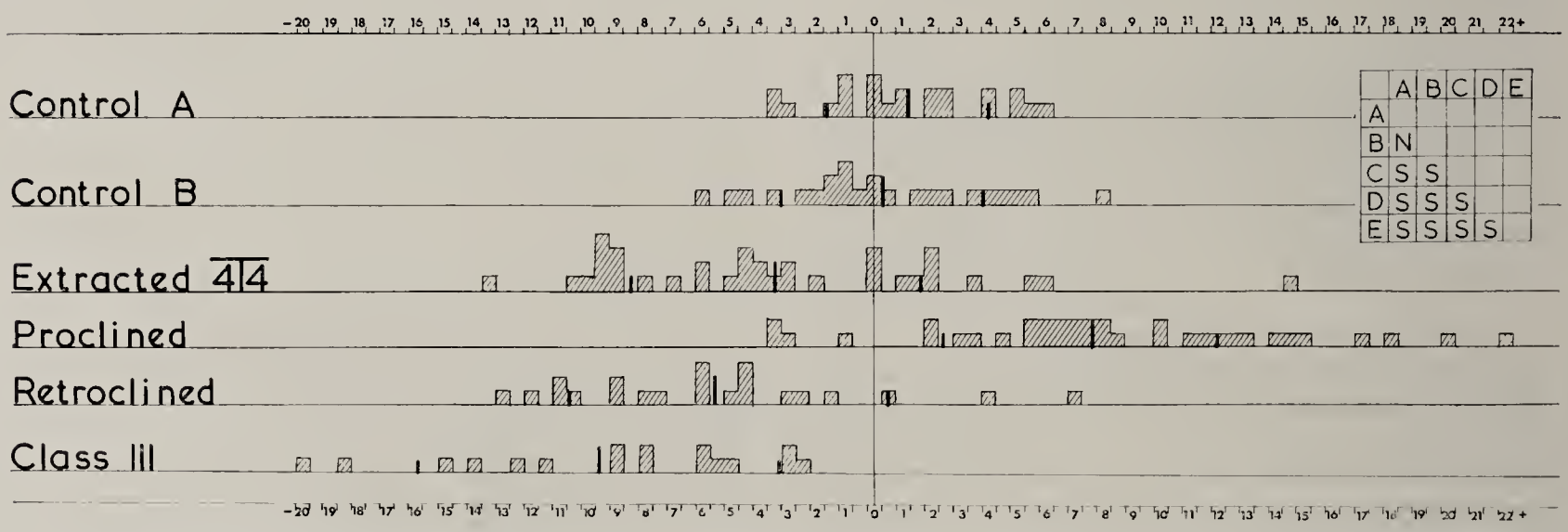
- 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 +
Control A
Control B
Extracted 4|4
Proclined
Retroclined
Class III
A B C D E
A
B N
C S S
D S S S
E S S S S

Fig. 5.—Series of histograms showing the changes in angle between long axis of lower incisor and mandibular plane in groups detailed in *Fig.* 2. The *inset* shows the significance or otherwise of differences between groups.

4–5° less proclined, while deliberate retroclination added only a further 2° retroclination to this (*Table III*).

Unfortunately, the average change gives us little idea of the change in a given individual, because of the wide range of response seen in all

Fig. 6.—Series of histograms showing changes in angle SNI in groups detailed in *Fig.* 2. The *inset* shows the significance or otherwise of differences between groups.

(*Fig.* 1 A), as a measure of the anteroposterior change in the position of the incisal edge of the lower incisor; I being the point where the long axis of the tooth cuts its incisal edge. This angle is inherently much more accurate than the previous one (Mills, 1966a), 66 per cent of our

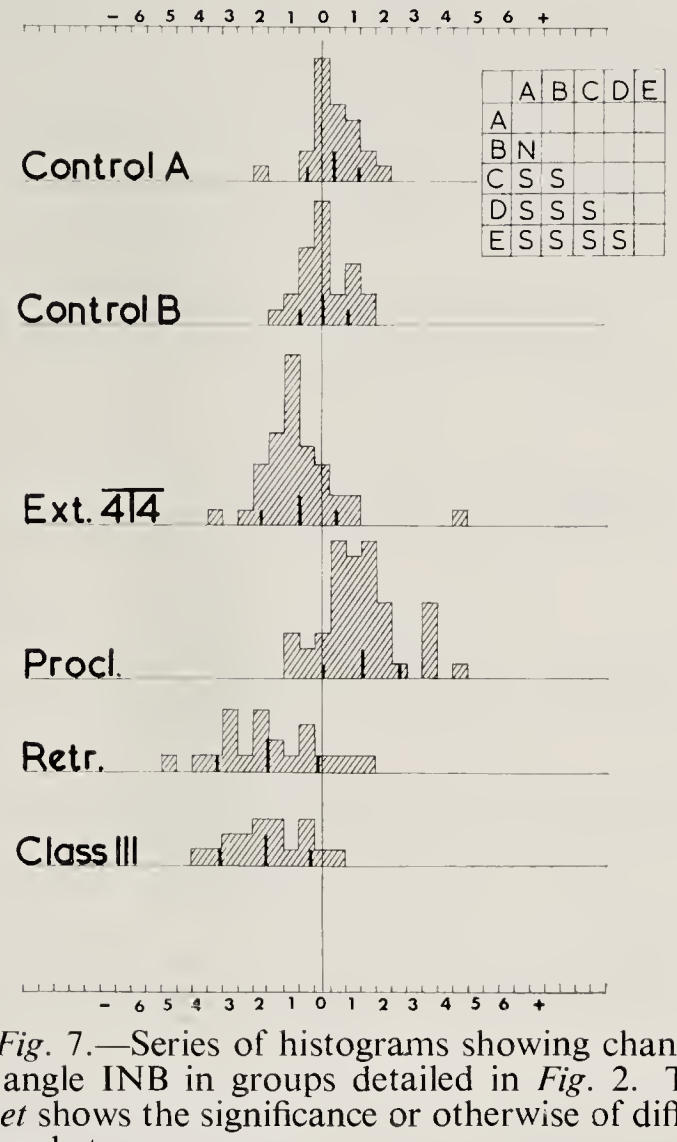

Fig. 7.—Series of histograms showing changes in angle INB in groups detailed in *Fig.* 2. The *inset* shows the significance or otherwise of differences between groups.

Table III.—Changes in Position of Teeth during Period of Observation

	Angle of $\overline{1\|1}$ to mandible		SNI		INB		SNL		LNB	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Control group A	+1·15	2·85	+1·59	1·50	+0·37	0·83	+1·56	1·49	−0·37	0·87
Control group B	+0·29	3·55	+0·56	1·62	+0·04	0·80	+0·53	1·38	+0·17	0·90
$\overline{4\|4}$ extracted	−3·42	5·42	−0·04	1·79	−0·78	1·29	+ 1·28	1·75	−0·47	0·66
Lower incisors proclined	+7·66	5·34	+2·04	1·88	+1·27	1·27	+0·51	2·21	+0·28	0·85
Lower incisors retroclined	−5·59	5·12	−0·93	1·60	−1·79	1·65	+1·39	1·82	−0·45	0·81
Class III group	−9·64	6·35	−1·28	2·41	−1·83	1·51	+1·86	2·40	−1·36	0·84

the groups. In considering occlusion, the most important part of the tooth is its incisal edge, which usually supports the cingulum of the upper incisor. I therefore measured the angle SNI

measurements here, and in subsequent angular measurements, being within about $\frac{3}{4}°$ of the true measurement. *Fig.* 6 shows that individuals depart much less from the average than in the

previous measurement, and this is reflected also in the standard deviation (*Table III*).

On average, there is a slight increase in this angle in both control groups, especially the younger. Where the first premolars have been extracted this forward movement of the lower incisal edge is absent, the angle remaining

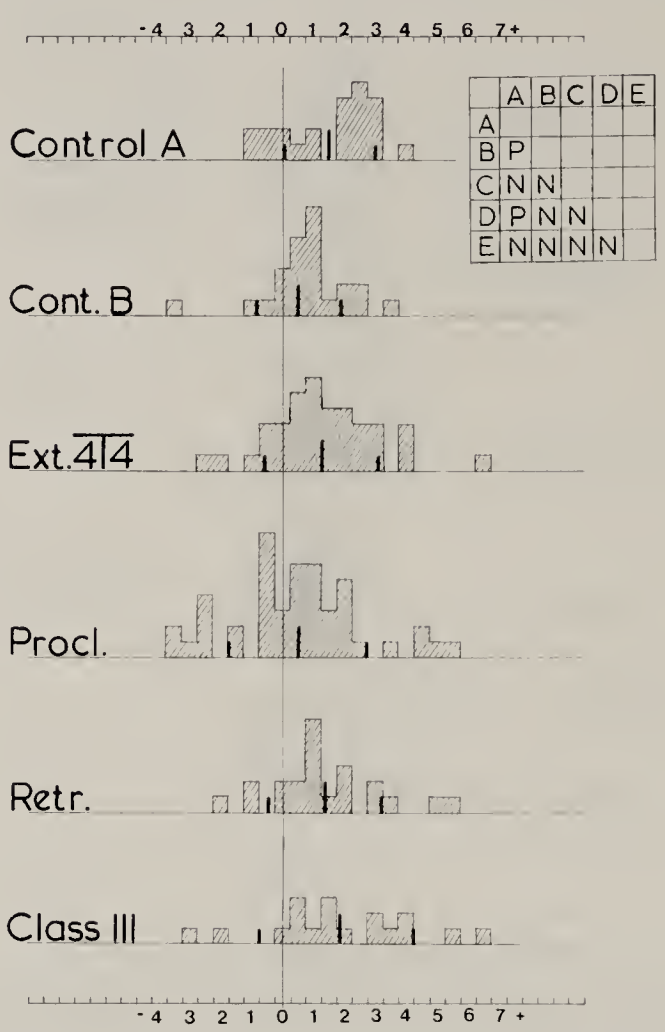

Fig. 8.—Series of histograms showing changes in angle SNL in groups detailed in *Fig.* 2. The *inset* shows the significance or otherwise of differences between groups.

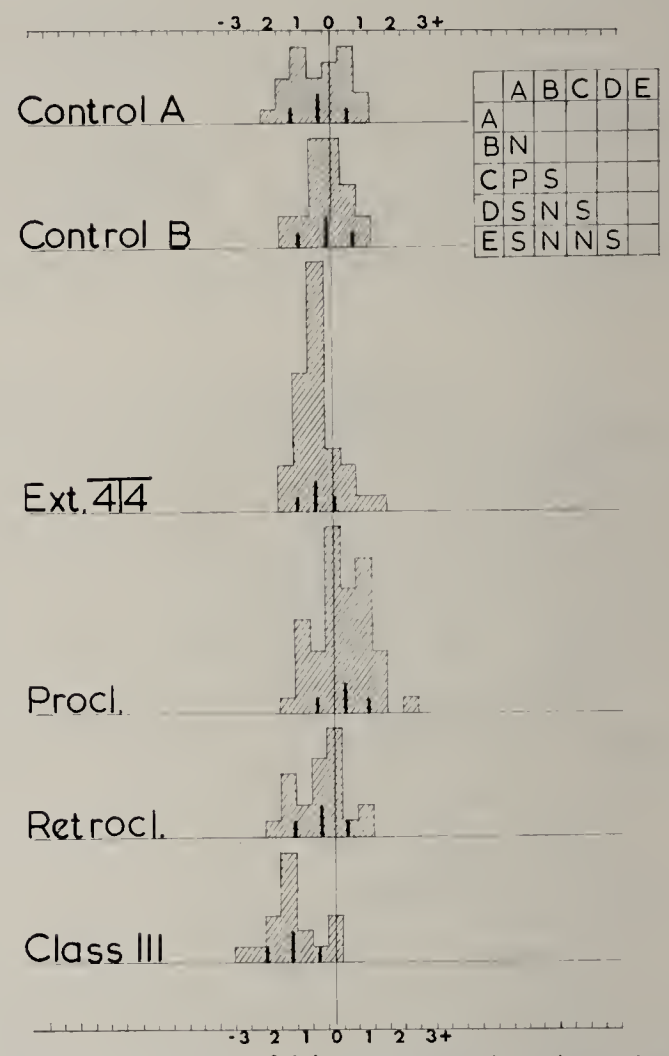

Fig. 9.—Series of histograms showing changes in angle LNB in groups detailed in *Fig.* 2. The *inset* shows the significance or otherwise of differences between groups.

virtually unchanged. Following mechanical proclination, the angle SNI ends up 2° greater, and following retroclination 1° less than originally. In the latter case it is surprising how little difference there is, in the long term, between Class III cases and those with a Class I or Class II incisor relationship. *Fig.* 6 (*inset*) shows that most of the differences of response between the groups are statistically significant, the exceptions being partly explained by age differences between the groups concerned.

The anteroposterior position of the point I relative to the line SN is affected partly by movement of the tooth through the surrounding alveolar bone, but also, to some extent, by relative anteroposterior movement of the anterior dental base. The latter, resulting from normal growth, is reflected in changes in the angle SNB. In an attempt to eliminate this factor, I therefore calculated the changes in the angle INB for each patient; that is the difference between SNB and SNI. *Fig.* 7 shows that the range around the mean value is here quite small, so that the average change is more likely to be applicable to a given individual. In round figures, the point I comes forward about $\frac{1}{3}°$ relative to point B in the younger control group, and does not change in the older group. Following proclination it ends up $1\frac{1}{4}°$ more proclined. If the lower first premolars are extracted, it drops back $\frac{3}{4}°$, this increasing to $1\frac{3}{4}°$ if the teeth have been mechanically retroclined. *Fig.* 7 (*inset*) shows that all these changes are significantly different from each other apart from the difference between the two control groups.

The same principle was used to investigate anteroposterior changes in the position of the root apex, as represented by the point L, where the long axis of the lower incisor cuts the apex (*Fig.* 1 A). Very much less change is seen here than was the case with the incisal edge. In the case of the angle SNL (*Fig.* 8) the differences between the groups are small and not statistically significant, although it is probable that, following proclination of the lower incisors, the root apex is further lingually than it would otherwise be.

When we turn to the angle LNB we find the standard deviations the smallest of any group (*Fig.* 9 and *Table III*). Examination of *Fig.* 1 A will confirm that in the case of this angle, unlike all the others considered, labial movement of the apex is represented by a decrease, and lingual movement by an increase in the angle.

Following extraction of the first premolars the apex moves slightly labially, the amount being unaffected by whether or not there has been appliance therapy. Following proclination, it moves lingually. The most striking difference is following mechanical retroclination, where three times as much labial movement is seen in the Class III group as in the Class I and II groups.

The changes in the angle LNB are extremely consistent, as shown by the standard deviations, and because of this the differences between many of the groups, although small, are statistically significant (*Fig.* 9, *inset*).

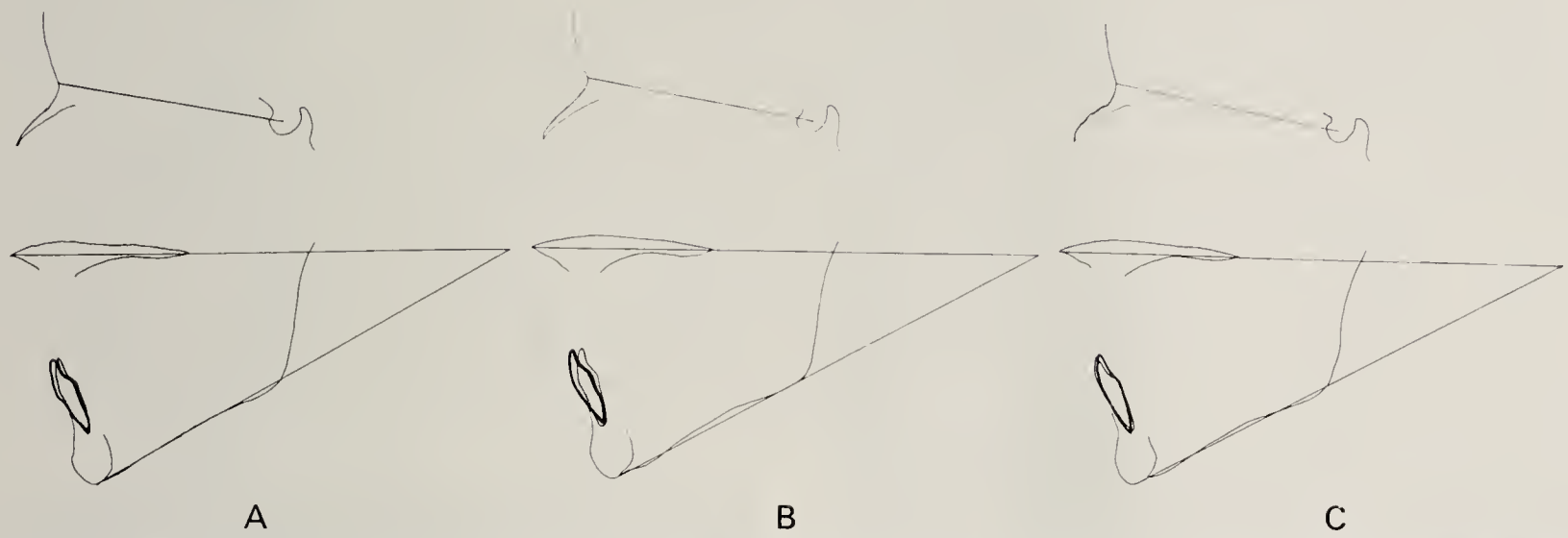

Fig. 10.—Diagram showing, on face of average dimensions, the position of lower incisor in absence of any treatment (thick outline) and also (shaded) following A, Loss of first premolars. B, Loss of premolars and deliberate retroclination of lower incisors. C, Proclination of lower incisors.

The Individual Groups

The Control Groups

It will be seen from the above figures that the change in the two control groups is similar in type, but differs in amount. The younger group covers a time when the child is actively growing, and for most individuals includes the whole of the pubertal growth spurt. In the older group puberty is virtually over, and growth is coming to an end. There is a slight increase in the angle SNB in both groups, and a decrease in the maxillomandibular planes angles; both changes reported by other workers in the field. The change in facial proportions is very small in both groups, the lower face becoming proportionately larger in the older group, but to a quite insignificant extent. The lower incisors tend to procline slightly relative to the mandibular plane, but this merely reflects the change of the mandibular plane angle rather than of the incisor, and relative to the line SN there is only minimal change.

The Effect of Lower Premolar Extraction

Fig. 10 is an ' artist's impression ' of the effect of the three types of treatment on the lower incisor, in a face of average dimensions. In each case the shaded outline shows the position the incisor would occupy following the appropriate treatment, while the thick, unshaded outline shows its position in the absence of treatment. This was based on interpolation from the two control groups. Every effort has been made to ensure accuracy in this diagram, using not only the figures given here, but others as yet unpublished. Nevertheless, these diagrams should be accepted as an approximate average picture of the response in the three cases, not necessarily exactly applicable to individual cases.

In *Fig.* 10 A we see the result of the extraction of lower first premolars. The most striking feature is how little change actually occurs. To describe this as a ' collapse ' of the lower incisors would seem an overstatement; indeed, the lingual tilting of the tooth, about a point slightly above the apex, is due to a failure of the incisal edge to follow the natural forward growth of the apex and the dental base, rather than to its actual lingual movement. I have shown elsewhere (Mills, 1967) that a change of 1° in the angle INB is equivalent to about 1·3 mm. of linear distance, so that in this case the incisal edge would end up about 1·5 mm. further lingually than if the teeth had not been extracted.

This is, of course, an average picture which will not apply to every individual, although if we relate it to the point B it will apply to most of them. I have previously investigated those cases which showed excessive lingual movement of the incisal edge (Mills, 1964), since these are the cases where the sequelae might be serious. In general these cases showed a similar picture. If the tracings of first and last radiographs were superimposed on the palatal outline, it was found that the mandibular dental base had grown forward relative to the corresponding maxillary base to an excessive extent, as illustrated in *Fig.* 11. The incisal edge had not followed, but had remained in its original relation to the *upper*

jaw, and had thus retroclined. In fact, we had exactly the same picture as in the average case, but retroclination was more marked because of the greater forward movement of the lower dental base.

Where a similar forward growth of the dental base occurred in the control group, some retroclination of the lower incisor may occur, with consequent crowding, the upper incisor may procline, or the pressure of the intact dental arch

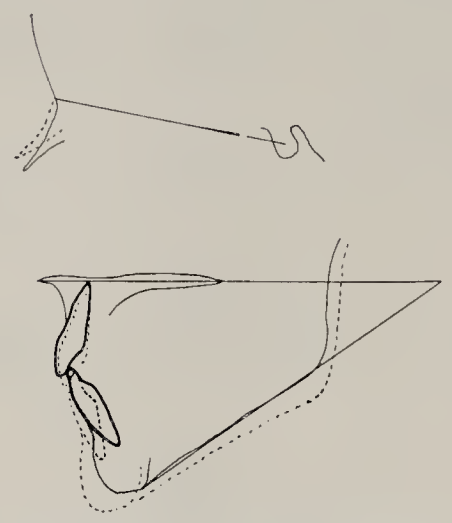

Fig. 11.—Tracings of case showing extreme retroclination of lower incisors following loss of $\overline{4|4}$, superimposed on maxillary outline. Solid line before treatment, broken line outline $2\frac{1}{2}$ years out of retention.

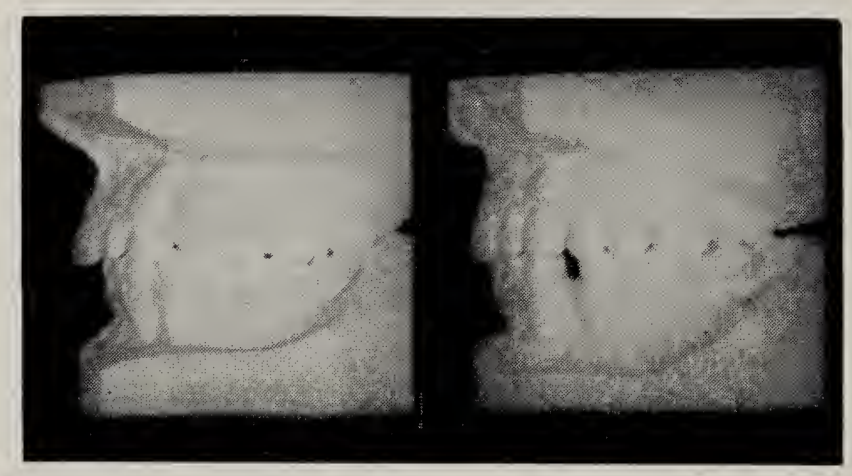

Fig. 13.—Models of same patient as *Fig.* 12 before treatment and $3\frac{1}{2}$ years out of retention.

may cause the incisal edge to move forward with the base, so that it comes to occlude further down the lingual cingulum of the upper incisor.

The Mechanical Retroclination of the Lower Incisors

Fig. 10 B shows the result of mechanical retroclination of the lower incisors following the loss of lower first premolars. The effect is to almost double the amount of lingual movement of the incisal edge, so that it ends a little over 2·5 mm. further lingually than would have been the case in the absence of treatment. There is little difference in this respect between cases where the incisors were initially in Class I or II relation on the one hand and Class III on the other, despite the change in relationship of upper and lower incisors in the latter group. On the other hand, in this latter group the incisor apex moves labially about 1·5 mm. more than in the Class I and II group, where labial movement of the apex is minimal.

The amount of movement in these cases is more noticeable clinically than in the previous group,

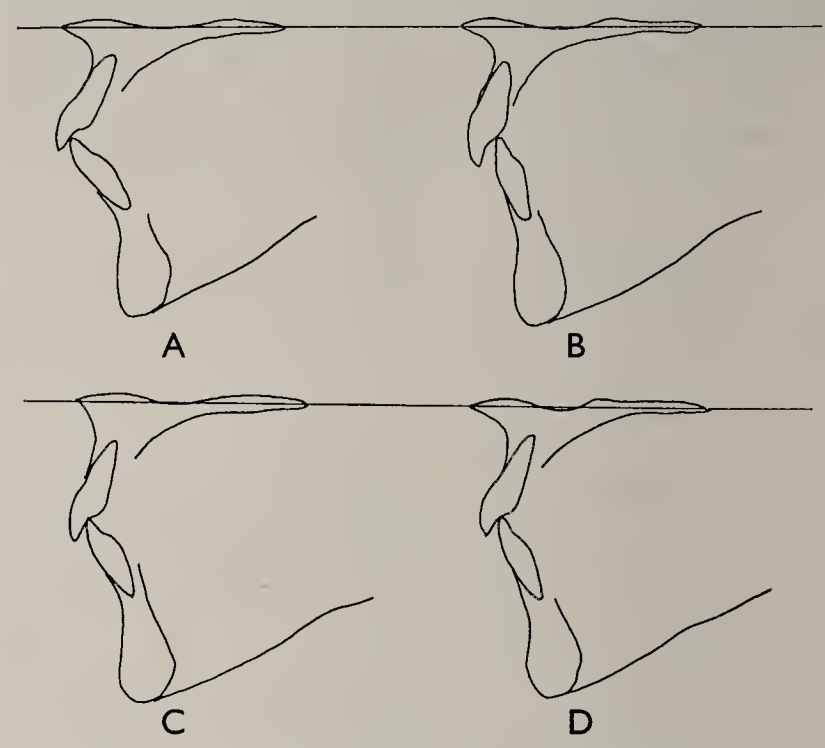

Fig. 12.—Diagram of jaws of a case of bimaxillary proclination. A, Before treatment. B, At end of retention, C, $3\frac{1}{2}$ years later. D, has been artificially produced from A by moving lower incisors lingually by average amount for group.

but it is still quite small. *Fig.* 12 A is the tracing of the lateral skull radiograph of a patient who exhibited bimaxillary proclination. In *Fig.* 12 B we see the same case at the end of retention, following lingual tilting of the lower incisors through 17·5°, with a decrease of SNI and INB of 4·0° and 4·5° respectively, and in *Fig.* 12 C, $3\frac{1}{2}$ years later. *Fig.* 12 D has been artificially drawn from *Fig.* 12 A, by moving the lower incisors lingually by the average amount one would expect following lingual retraction, and moving the upper incisors into contact with them. It will be seen that the average figure (*Fig.* 12 D) is very similar to the result actually obtained (*Fig.* 12 C)—which is why this case was selected. *Fig.* 13 shows the models of the same patient before treatment and $3\frac{1}{2}$ years out of retention. Although there is an undoubted difference following treatment, it is doubtful whether the improvement obtained would justify the effort involved; certainly neither I nor the patient believed it to be so.

Once again an attempt was made to identify the type of case in which extreme retroclination might be achieved; the variation in response is greater for this type of treatment than for either of the other two major experimental groups. As in the previous group, it was found that retroclination was greatest where the lower dental base grew forward relative to the upper, while the incisal edge was restrained by the upper incisor

(*Fig.* 14). Such a response is unpredictable in the present state of our knowledge.

The Proclination of Lower Incisors

The average effect of proclining the lower incisors is shown in *Fig.* 10 C. The incisal edge ends up about 1·3 mm. further labially than it would otherwise be—surely a wholly negligible amount—while the root apex is very slightly

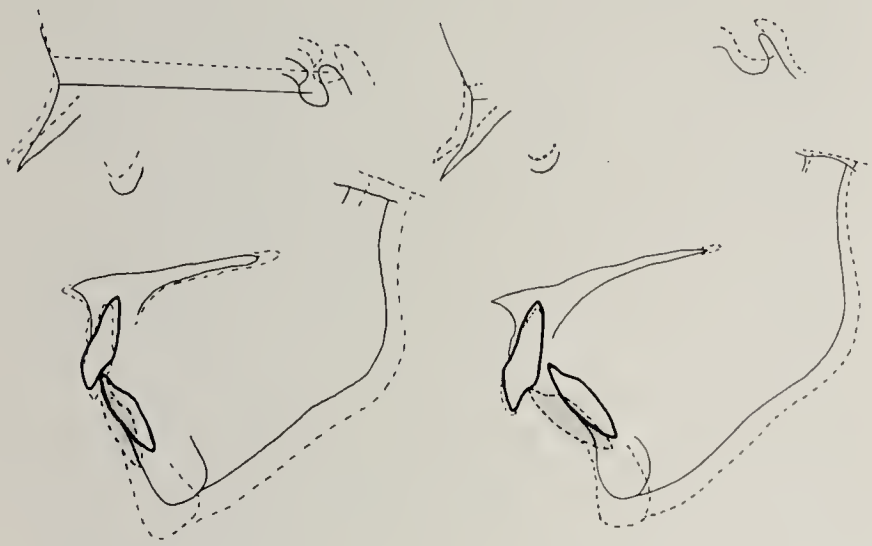

Fig. 14.

Fig. 15.

Fig. 14.—Tracings of case showing extreme retroclination of lower incisors maintained, following deliberate mechanical retroclination, superimposed on maxillary outline.

Fig. 15.—Tracings of case showing extreme successful proclination of lower incisors, superimposed on maxillary outline.

lingually displaced. The incisors are $6\frac{1}{2}^{\circ}$ more proclined than they would otherwise be.

In the previous article (Mills, 1966a) I again considered the extreme cases, where successful proclination had been held over a number of years. In a few cases this followed the cessation of thumb-sucking; the teeth having been retroclined by the thumb, they readily returned to their true angulation when the habit ceased. The majority of successful proclination fell into a group illustrated in *Fig.* 15. These were cases, either Class II, division 1 or 2, where the lower incisors occluded against the palate lingually to the upper incisors. Because of the steep anterior slope of the palate in this type of case, the incisal edge was not only lingual to but also well above the cingulum of the corresponding upper incisor. In the previous paper I suggested that this was the result of lip activity, but I am now more inclined to think that it is brought about by the palate itself, which mechanically holds back the incisal edge as the mandible develops forward, since the condition occurs in both divisions of Class II malocclusion.

CORRELATIONS

An attempt has already been made to identify subjectively the types of occlusion in which extreme or atypical responses might be expected in the three types of treatment considered. In a further attempt to identify the factors which influenced the response, several statistical correlations were calculated.

The most interesting of these are described below:—

1. Initial Incisor Angle

It might well be thought that the angle of the lower incisor to the mandibular plane at the beginning of treatment would influence the extent to which the tooth could be proclined or retroclined. *Fig.* 16 shows scattergrams for the three major experimental groups, by plotting the original incisal angle against the overall change in this angle. The correlation coefficient following extraction of first premolars was 0·107, following mechanical retroclination was 0·160, and after proclination, 0·240. None of these was statistically significant, and the only one which remotely approaches significance is the last (approximately the 0·10 level). This may have been influenced by the fact that the few cases where successful proclination was achieved would probably start with retroclined lower incisors—the result of a thumb, or of occlusions against the anterior palate. These, however, are special cases, and the scattergram shows many cases with initially retroclined lower incisors which were not successfully proclined. One cannot predict the amount of movement which will take place, in any of the groups, from a consideration of the initial incisal angle.

2. Relapse Relative to Amount of Tooth Movement

For certain tooth movements, notably rotation of teeth, the amount of relapse following retention seems to be the same irrespective of the amount of movement achieved, so that allowance can be made by overcorrection. Was this the case here? This is not an easy factor to investigate. Radiographs were available which were taken during treatment, and from these we selected for each patient that which showed the maximum amount of proclination or retroclination. The difference between the angle INB in this and the initial radiograph was taken to represent the maximum change in this angle, and the difference between this and the final radiograph, the amount of relapse. The scattergrams in *Fig.* 17 were produced by plotting the maximum change against relapse. The correlation coefficient for retroclination was 0·594, and for proclination 0·412. Both of these are significant, at the 0·01 level. There can be no doubt that the more one proclines or retroclines the tooth, generally speaking, the more it will relapse. Over-treatment is not the answer in this case, provided the teeth are moved to the maximum permissible extent in the first instance.

3. Relapse as a Function of Time

All the cases considered in this study were at least one year out of retention. Was this sufficient, or were the teeth still relapsing for long after this? To answer this question I calculated correlation coefficients between the relapse in the angle INB and the length of time out of retention for the two groups where lower appliances had been worn. Scattergrams for these factors are shown in *Fig.* 18. Following retroclination, the coefficient was 0·198, and following proclination 0·310. The former was in no way significant, but the latter just reached the 0·05 level of significance; a very low level when we are considering a number of correlations. It is therefore possible that following proclination the relapse continues, in some cases, for longer than 1 year out of retention, although this does not seem to be so following retroclination.

Where lower first premolars had been extracted without lower arch treatment this correlation could not be calculated, but the corresponding one seemed to be that between the total amount of change in the angle INB and the total time of observation. Did the lower incisors continue to ' drop lingually ' indefinitely, or did the process

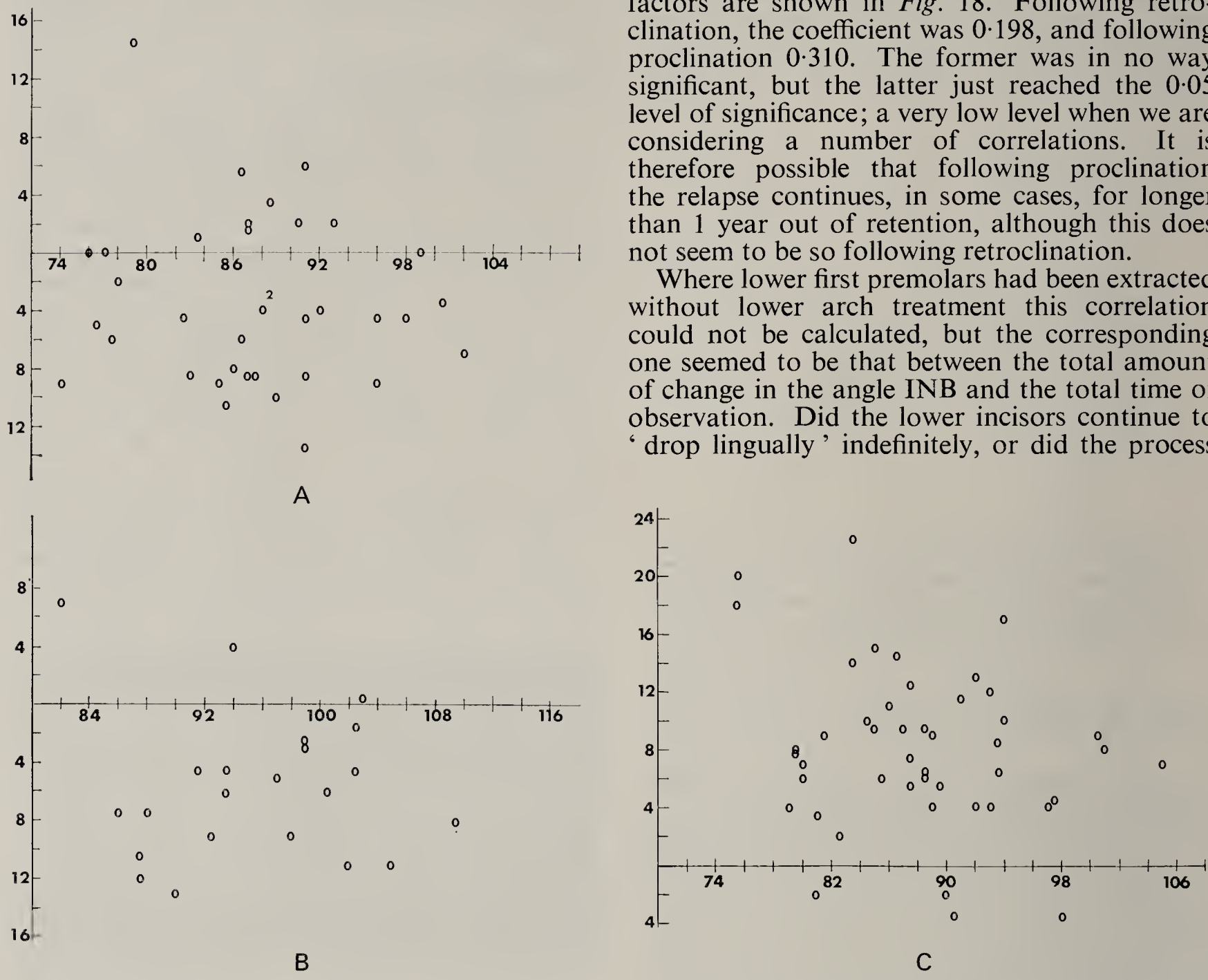

Fig. 16.—Scattergrams of initial lower incisor angle (horizontal ordinate) plotted against change of incisor angle. (Proclination shown above and retroclination below the horizontal line.) A, Following extraction of $\overline{4|4}$. B, Following retroclination of lower incisors. C, Following proclination of lower incisors.

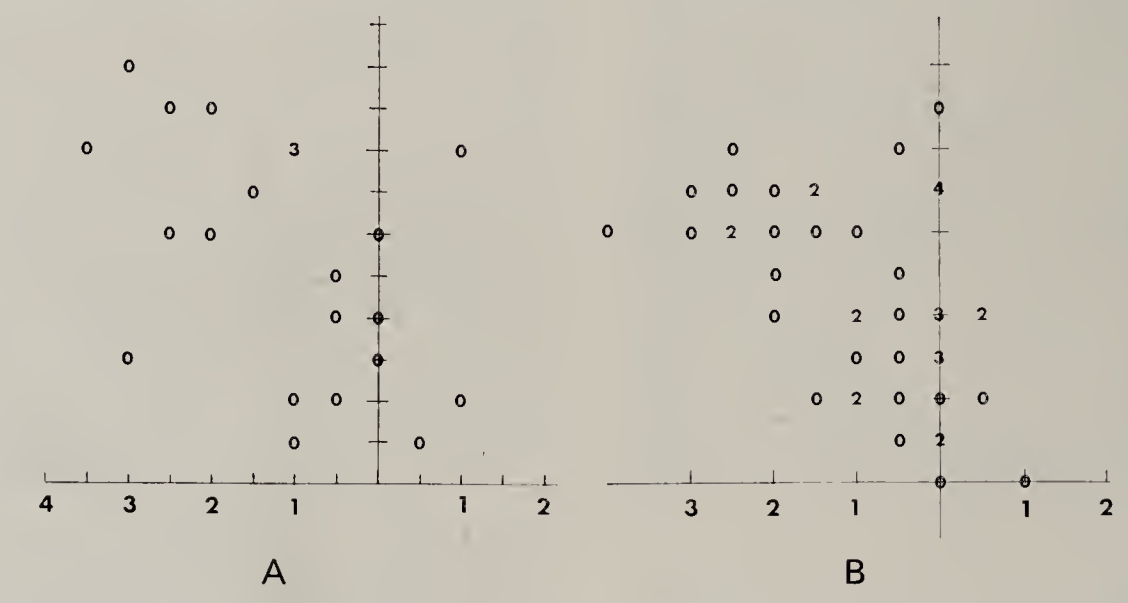

Fig. 17.—Scattergrams showing relapse of angle INB (horizontal ordinate, with relapse increasing to left of diagram) plotted against maximum change achieved. The small figures indicate where a number of points coincide. A, Following retroclination of lower incisors. B, Following their proclination.

cease after the first couple of years? The shortest time of observation here was 2·40 years, and the longest 8·45 years, so we have no knowledge of the happenings in the first $2\frac{1}{2}$ years. The results of this part of the study are shown as a scattergram in *Fig.* 19; the correlation coefficient of 0·204 did not reach any acceptable level of significance. There is, however, one rather odd feature about it. The correlation, weak and statistically insignificant though it is, would indicate that increase in time would be associated not with greater lingual movement of the lower incisors, but with less.

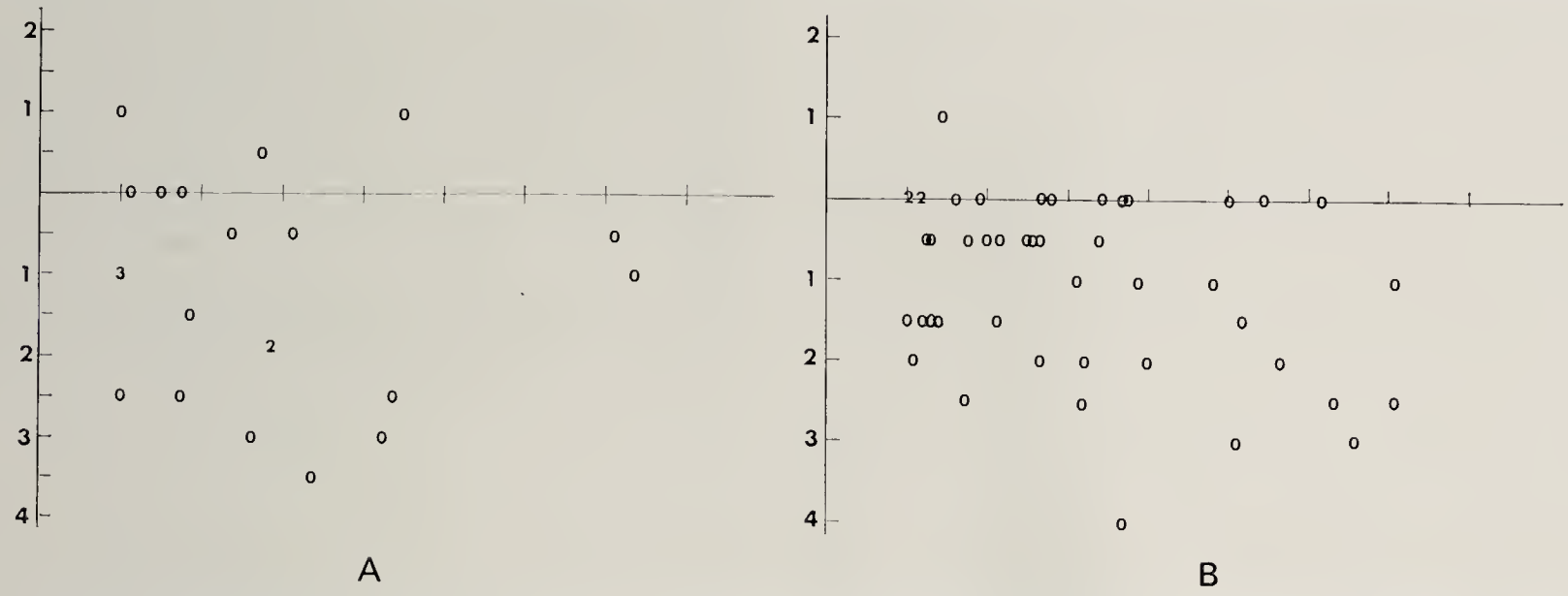

Fig. 18.—Scattergram showing relapse of angle INB (vertical ordinate, with relapse increasing as one passes downwards) plotted against time out of retention (horizontal ordinate, in years). A, Following retroclination of lower incisors. B, Following their proclination.

This may well be a chance finding, but a possible explanation would seem evident. At some time after the extraction of the lower first premolars the space usually closes, and it might be that, following this space closure, the lower incisors begin to return towards their original position. I felt that it would be interesting to see if this were so in individual cases. *Fig.* 20 shows the result in 6 cases. These were selected because they were the only cases in whom we had records extending over at least 6 years, with at least 2 radiographs taken after the spaces had closed. It was difficult to assess the exact moment of space closure, but study models were available, and one could say that the space closed at some time between the date of the last model to show a space and the first to show the canine and second premolar in contact. In *Fig.* 20, therefore, closure took place in each case during the period of time represented by the shaded area on the horizontal ordinate.

Changes in the angle of the lower incisor to the mandibular plane are shown by the broken line, and in the angle INB by the solid line; in each case points above the ordinate represent labial movement of the incisal edge and those below it lingual.

It will be seen that in all but one case the incisal edge seems to move lingually in the early stage of treatment, but that this direction is reversed later in the period of observation. This change in direction tends to occur about the time that the extraction space closes. The exception is the penultimate case where the reverse is true; the incisal edge moves labially until the extraction space closes, and then commences to drop lingually. This is difficult to explain, but clearly space closure is not the only factor at work, and the growth pattern in this girl was distinctly unusual.

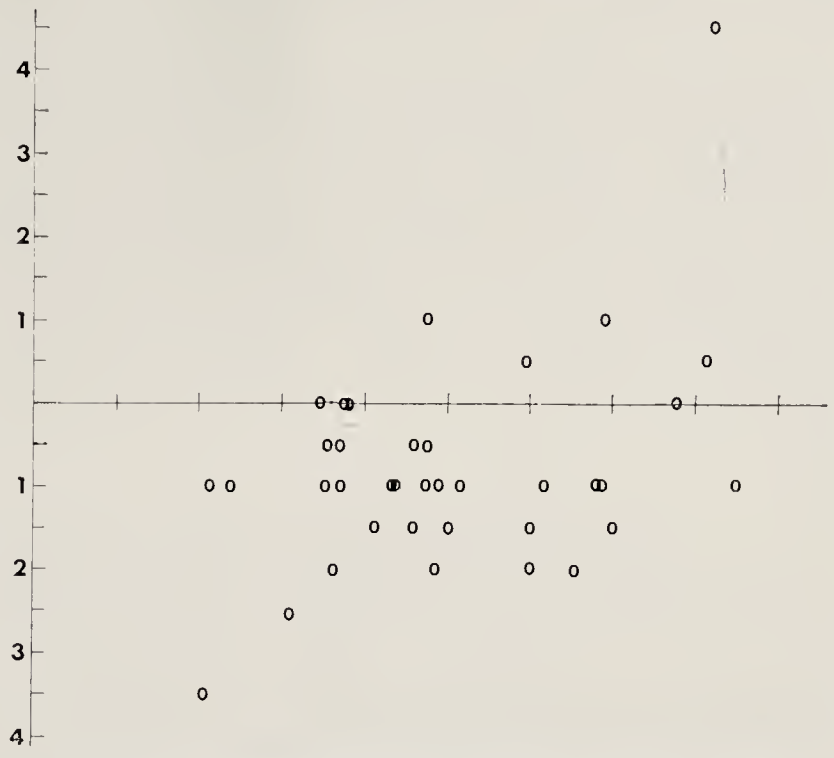

Fig. 19.—Scattergram showing overall change of angle INB (vertical ordinate) plotted against overall time of observation (in years), following extraction of $\overline{4|4}$.

DISCUSSION

It would seem, therefore, that the lower incisors lie within a very narrow zone of stability. Presumably this is controlled by a balance of muscle forces, although the details are outside the scope of this paper. The presence or absence of buccal

support to the labial segment will make a difference of only a little over a millimetre to their labiolingual position, while deliberate proclination of an intact arch or retroclination following

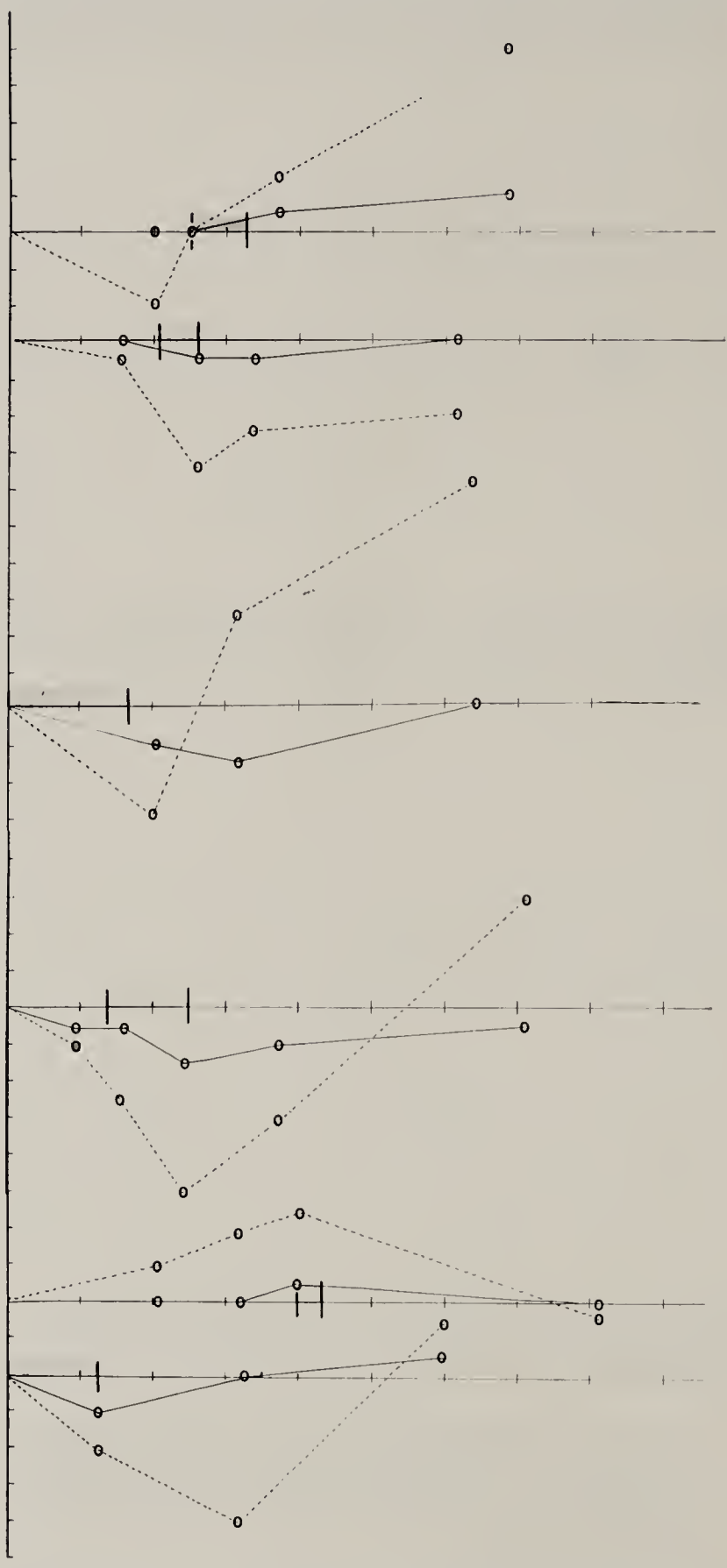

Fig. 20.—Changes in lower incisor inclination (broken line) and angle INB (solid line) in six individuals followed over at least 6 years. Labial movement of incisal edge shown above the line, and lingual movement below this line. Horizontal ordinate marked in years. The lower premolar space closed during the period shown by shading.

extractions will make a further difference of 1 to 1·5 mm. For practical purposes, these differences are negligible.

In exceptional cases a degree of permanent anteroposterior movement of the lower incisors may be achieved, greater than one would expect from the average figure. Where this involved retroclination of the lower incisors as a result of lower premolar extraction, with or without appliance therapy, the picture tended to be rather deceptive. In some cases, the lower dental base grows forward to an unusual extent, and the failure of the incisal edges to keep pace with this forward growth is responsible for the retroclination of the teeth and the posterior movement of point I relative to point B. Such cases are unpredictable in the present state of our knowledge. Even where the incisor relationship was deliberately changed, in the treatment of Class III malocclusion, the effect of the incisal edge is no greater than that described above, although

Fig. 21.—Showing proclination of lower incisors resulting from prolonged wearing of upper bite plane in Class II, division 2 patient.

the teeth tilt further lingually due to greater labial movement of the root apex. The treatment of Class III cases has been discussed elsewhere (Mills, 1966b).

We may have a rather better chance of predicting those cases where an unusual amount of proclination is possible. If a force is present which is causing the incisors to be displaced lingually, and we can remove that force, then the incisors will accept some proclination. This is the case where digit sucking can be eliminated, and also, in certain types of Class II malocclusion of either division, where there is a complete overbite. In this latter, rare, type of case the lower incisors come to occlude with the palate lingual to the upper incisors. Because of the unusually vertical shape of this part of the palate, it restrains the forward movement of the incisal edge as the mandibular base grows forward. If the overbite can be reduced to normal proportions, then some degree of proclination is possible. The problem, even here, is to estimate the amount of proclination which will remain stable. Probably the best solution is to reduce the overbite, perhaps with an upper anterior bite plane, thus releasing the lower incisors from

restraint and allowing them to take up their true position spontaneously.

A case treated in this way is shown in *Fig.* 21. This patient presented at the age of 9 years with his upper central incisors severely retroclined, and the overbite so deep that the upper incisors were traumatizing the lower labial gingiva, at a time when the upper lateral incisors had not yet erupted. He wore a series of upper removable appliances with flat anterior bite planes, of which the height was gradually increased. In this case these were worn for a total of 7 years, although it is not suggested that this period of retention would be necessary in the average case. Four premolars were extracted at 13 years, and some local tooth movement undertaken with removable appliances on the upper lateral incisors, canines, and remaining premolars. There was no treatment in the lower arch, and the upper central incisors were also untreated. Nevertheless, following substantial reduction of overbite with the bite plane, the lower incisors took up the position shown in *Fig.* 21. They had proclined 14·5°, with the angles SNI and INB increasing by 6·0° and 4·5° respectively. The final radiograph was taken 1 year, 4 months after all appliances were discarded, and during this time there has been no apparent relapse, either clinically or from lateral radiograph analysis.

I would suggest that the facts outlined above provide the key to successful planning of orthodontic treatment. This key lies in the labiolingual stability of the lower incisors, which gives us a datum from which to plan. We therefore begin by examining these incisors to see if there is any factor which is preventing them from taking up their true position of balance. Such cases are excessively rare. In the absence of such a factor, the labiolingual position of the lower incisors must be accepted. If they are crowded, then this crowding must be relieved by moving them distally, along the arch. This will usually involve extractions of more posterior teeth, and distal retraction of teeth anterior to the extractions. Any crowding in the lower buccal segments would similarly be corrected by suitable extractions.

Having, *in the mind's eye*, corrected the lower arch, the upper arch is then positioned over the lower. The key tooth here is the upper canine, and usually this would be placed to occlude between the lower canine and the premolar posterior to it. Where such full retraction is not desirable, as in some Class II cases, we should decide at this stage the amount of upper canine retraction which is required. Again, the distal movement of the upper canine will require extraction and/or distal movement of the more posterior teeth in the upper jaw.

Finally, the upper incisors are mentally corrected, and this enables one to decide whether overbite reduction is necessary.

I would emphasize that the above approach is a purely mental exercise, which enables one to decide which extractions are necessary, and exactly where each tooth should be placed. When we come to carry out treatment a different approach may well be preferable, the two arches being treated simultaneously or even the upper first. Nevertheless, the first principle should be to leave the labiolingual position of the lower incisors unchanged, except in the very rare cases which I have described.

Acknowledgements

I wish to thank my colleagues at the Eastman Dental Hospital, London, especially Professor C. F. Ballard and Mr. S. G. McCallin who have generously allowed me access to the records of patients treated under their care, to Miss G. T. D. Pickard, who traced and measured the radiographs and Miss J. Jeffery for secretarial assistance.

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DISCUSSION

The President asked Dr. Mills to comment on the possibility of moving the lower incisors with square brackets and edgewise arches deliberately to change the axial inclinations.

Dr. Mills replied that the edgewise technique had been used in a few cases, including the one illustrated in *Fig.* 12, where the tooth had been tilted about its apex.

He had not been able to notice any difference between these and other cases.

Mr. C. D. Parker wished to enquire about changes in overbite in the various groups. The question was raised because changes in the vertical relationship of the incisor teeth often occurred during observation, and, in particular, during orthodontic treatment. These changes inevitably affect the position of labiolingual balance of the incisor teeth, which, in turn, often produce a change in their angulation.

Dr. Mills replied that the question of overbite was one which Mr. Parker had studied and knew far more about than he himself did. He had the impression that in those cases where the lower incisors had been successfully proclined, there had initially been a very deep overbite but that this reduced rapidly when a bite plane was inserted, allowing them to be proclined quite readily.

Mr. T. D. Foster asked if Dr. Mills would say that, as a result of his findings on the stability of the lower incisal arch, the idea of the necessity for balancing extractions from one arch to the other when lower teeth have to be lost through caries would need to be revised and that there was no need to balance extractions from one arch to the other if the lower incisal arch was stable.

Dr. Mills replied that his own feeling was that if extractions were made in one arch, this was normally done because of crowding and if it was done in one arch, the chances were that the other arch would also be crowded, at least potentially. On the whole, he would usually balance extractions. He thought one was very likely to get into trouble of one extracted in the upper arch only, but then, towards the end of treatment, changed one's mind and extracted lower premolars.

Mr. I. F. Davidson said that he had had a number of bimaxillary proclinations referred in recently and had had to retain some of them for treatment despite advice to the contrary. What did Dr. Mills consider was the best way of taking back the lower incisors?

Dr. Mills said he did not think there was a good way of treating them. His usually seemed to relapse. In the present sample, it did not seem to make much difference what appliances were used.

Mr. D. G. Gould asked Dr. Mills if he thought the lower lip had any influence on the position of the lower incisors. He was thinking of cases where sometimes the lower lip got under the upper incisors and of other cases which had been described as the ' strap-like action of the lower lip '.

Dr. Mills said that the lower lip must obviously have an effect on the lower incisors. This was basic to orthodontic theory. When he had first written about proclination, he had suggested that where there had been successful proclination, it was because, at the beginning of treatment, the lower lip was between the upper incisors and at the end of treatment, it was outside and was therefore not having the same effect. He was now less inclined to think that this was so.

The so-called ' strap-like activity of the lower lip' undoubtedly caused retroclination of the lower incisors, but he thought it caused it anyway and the incisors would go back whether the arch was intact or not. But the continuity, or otherwise, of the arch would have the same effect on these cases as others, so far as further retroclination was concerned.

Mr. A. S. Lewis asked Dr. Mills about the tracing of the X-rays and whether he took the most proclined lower incisor in crowded cases. Would this make a difference after the extraction of lower first premolars, so that once the lower arch was evened out, the most proclined incisor would be level with the other incisors? Would this account for the retroclination?

The second question concerned treatment with fixed appliances and bodily movement. He thought Professor Ballard felt that lip action acted on the alveolus, and therefore stable bodily movement of the incisors would take place with retroclination of the apex and proclination of the incisal edge. Had Dr. Mills tried any of this type of treatment in these cases?

Dr. Mills, answering the second question first, said that where the lower incisors were proclined, with the apex going lingually—and there were all possible variations including some where the lower apex went lingually—generally speaking, one found that the apical movement relapsed less than the incisal edge movement, but relapse was not absent.

On the first question, in fact, the most proclined lower incisor had been traced. The reason was that it was the only lower incisor that could be seen fairly clearly. What had been done was to look at the series of radiographs that showed the lower incisor most clearly, this was traced on to a small piece of tracing paper and used as a template of all the other X-rays. Mr. Lewis' point was a perfectly valid one.

Dr. P. H. Démogé said he had been interested in lower incisors, their position and behaviour for some years. In his experience, one of the toughest things was to find the apex of the lower incisors on a lateral X-ray. Since some of the angles which had been used, such as INB and LNB, were extremely small, point N being at a considerable distance from points I and L, and since very precise measurements with protractors were difficult, he had two questions:—

Firstly, did not Dr. Mills think that using linear measurements rather than angular measurements would improve accuracy? Secondly, had Dr. Mills tested the chances of error in relation to the very small readings in angular measurements encountered? Was it not possible that during the period which elapsed between successive lateral radiographs of the same patient, calcification of the apices might provide a better definition; and if it was the case, could it not be an added cause for variations in measurements?

Dr. Mills said that Dr. Démogé had seen the point all too well. The inaccuracies had been calculated by double determination. About 60 X-rays had been traced twice. Using Dahlberg's formula to calculate the ' Error of Method ' he found most of the angles were such that two-thirds of his readings should be accurate to within $\frac{3}{4}°$. With a fairly long ' arm ' to the angle this would make some difference. There was no reason to think the error was such that measurements in later radiographs were consistently higher or lower than earlier ones, and if this was correct, the error would not affect the mean values, but would make the standard deviations appear larger than they should.

Mr. A. G. Huddart said he thought it was important to appreciate that it was, in fact, the position of the lower central incisors which had been studied.

From the paper, it would appear that lower extractions had little effect on the position of these teeth, but what was the effect of the extractions on the positions of the lower lateral incisors and canines, and on the shape of the anterior part of the lower arch?

Dr. Mills said that much could be done by looking at the models. These teeth could not be seen at all well on the lateral radiographs. One thing he had done for his own amusement on one occasion, where the lower first premolars were extracted, was to see what happened to the lower canines. Many people believed that the lower intercanine width was inviolable and could not be increased. It was interesting that in this case where they drifted distally along the arch, it had increased. He thought the maximum was 4 mm. Apart from that, he could not say what the average was because he had not worked it out.

COMPARISON OF THE OCCLUSION IN A PAIR OF TWINS

W. FRANKLAND, B.D.S., D.Orth. R.C.S.

This case report concerns identical twin boys aged 11 years who were referred for orthodontic treatment. They both show the remarkable presence of bilateral supernumeraries in association with the unerupted $\overline{5|5}$ (*Fig.* 1). The other interesting feature is that whilst the malocclusion is basically similar in both cases, consisting of crowding of upper and lower arches on a mild Class III base relationship, there are some quite significant differences in detail.

1. Perhaps the most marked is that the palatally crowded $\underline{2}|$ which is illustrated in *Fig.* 2A2 is completely in lingual occlusion, whilst that which is illustrated in *Fig.* 2A1 is approximately edge-to-edge.

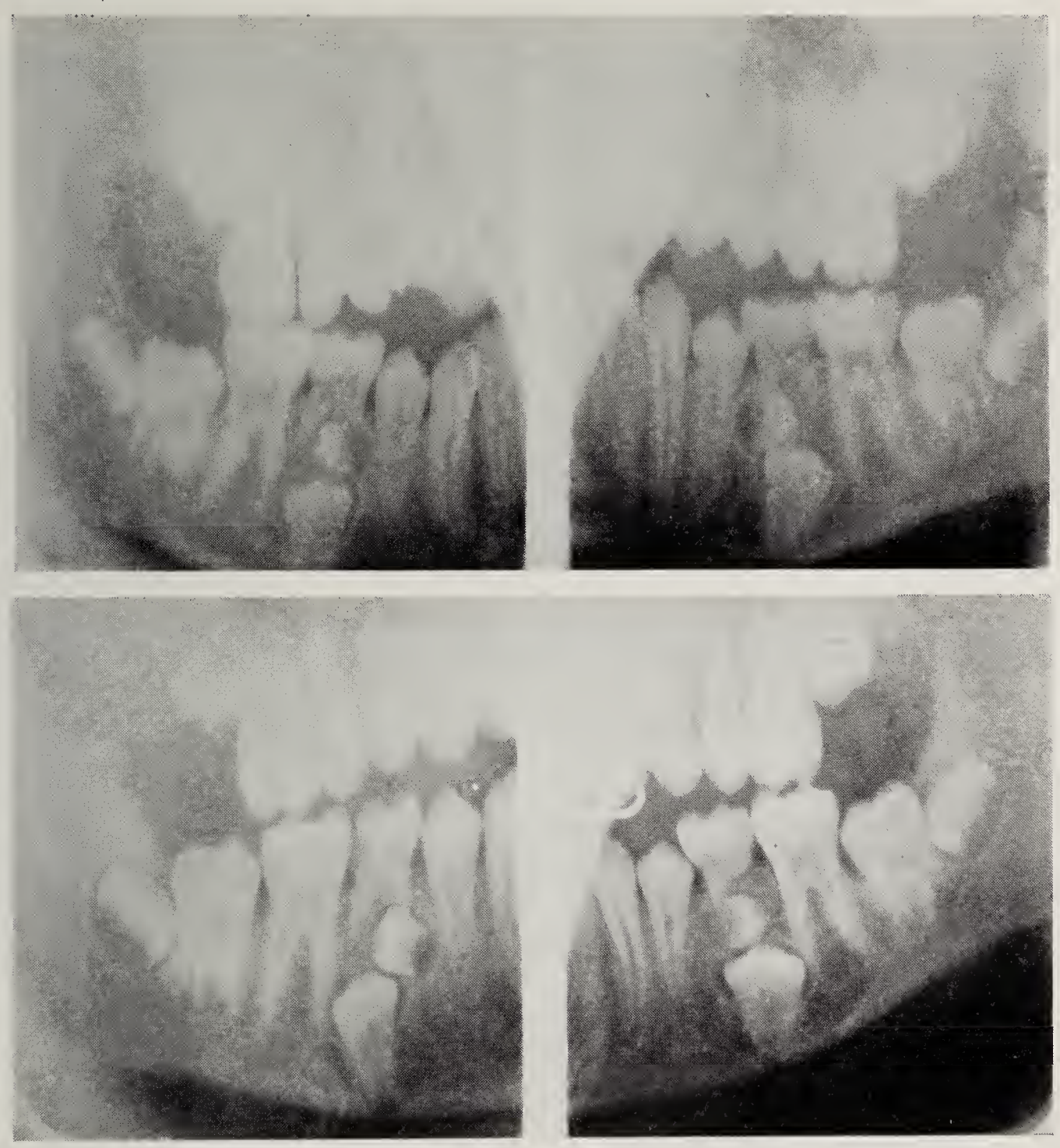

Fig. 1.—Radiographs of the twins to show unerupted lower supernumerary premolars.

2. The degree of mesial displacement of the upper canines is greater in 1 than in 2, this being more marked on the right side (*Fig.* 2B, C).

3. The pattern of crowding in the lower labial segment is rather different, with 2 having $|\overline{2}$ more

Presented at the meeting held on 13 November, 1967.

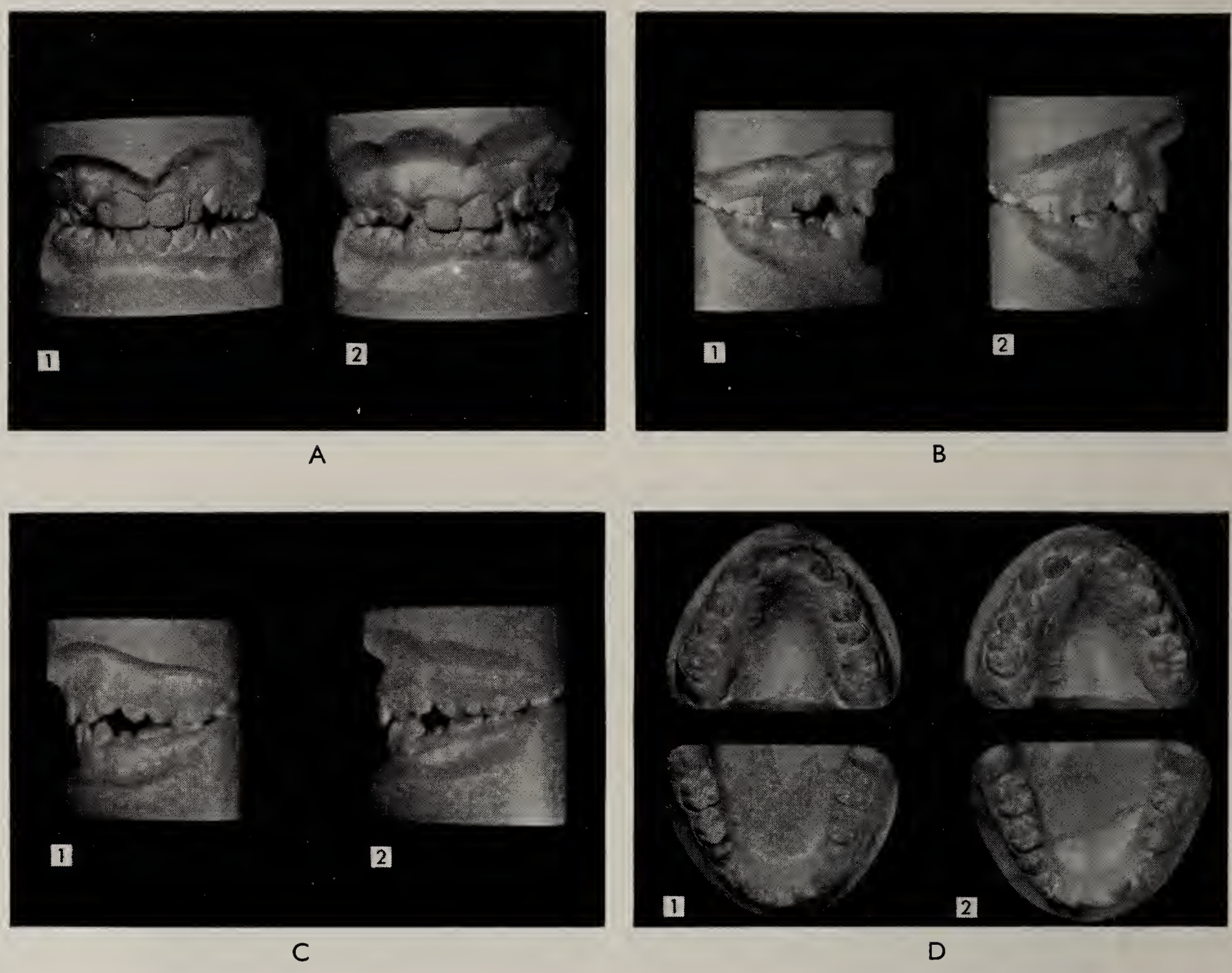

Fig. 2.—Models of the dentitions of the twins. A, Anterior view; B, Right lateral view; C, Left lateral view; and D, Occlusal view.

lingually placed and without the mesiolingual rotation of that in 1 (*Fig.* 2D).

It is felt that the differences in the two occlusions are notable enough to be of interest in view of the otherwise remarkable similarity of the dentition, suggesting that there is scope for variation of the occlusion on the same genetic pattern.

DISCUSSION

Dr. J. R. E. Mills said that he had seen one or two cases in which apparently identical twins had slightly different malocclusions. His impression in each case had been that there was a small difference in arch size, although apparently the teeth had been identical and this had triggered off the difference in occlusion. He wondered whether Mr. Frankland thought that this was because the arches were different in size.

Mr. Frankland replied that he had not done actual measurements. His own feeling was that this could be put down to chance variations on the same genetic pattern.

Mr. J. R. Pettman said that a pair of identical twins he had seen, without thorough identification of their identity, had some mirror image similarities in their malocclusions and ipsilateral similarities in details of tooth morphology, which he had thought fascinating. For example, one had a left crossbite of the molars, the other had a right crossbite; whereas one had a large tubercle on an upper left molar, the other also had a large tubercle on the upper left molar.

Mr. Gardiner said that he was interested in what Mr. Frankland was going to do with the twins now. If the mother could be persuaded that one twin should be treated and not the other, or that they should be treated in different ways, a great deal could be learnt.

Mr. E. S. Broadway reported, as a like twin, that his brother had an unerupted lower canine and he himself had both lower canines. He thought this was just a local peculiarity which could occur in anyone and was not necessarily anything to do with being twins.

Mr. R. T. Broadway pointed out that he had one more lower incisor than his brother.

Mr. E. S. Broadway pointed out that his brother had knocked his out!

THE SURGICAL REPOSITIONING OF LABIAL SEGMENTS IN THE TREATMENT OF MALOCCLUSION

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ORTHODONTISTS by definition treat malocclusions, but we sometimes forget that our oral surgery colleagues may be primarily consulted about certain types of malocclusions and be required to treat them with or without orthodontic help.

Typically, these are older patients with severe Class III and Class II, division 1 malocclusions. A major osteotomy will treat the former type of case very adequately and extractions, alveolectomy, and a denture will satisfy the latter type. However, in the less severe Class III cases the major osteotomy may disrupt skeletal proportions too much and in severe Class II, division 1 cases the patient may wish to have improvement without loss of teeth. The localized osteotomy, as pioneered by Spanier (1932) and Wassmund (1935), and more recently described by Schuchardt (1942) and Kole (1959, 1965), appears to offer a solution to the oral surgeon in this dilemma.

The osteotomy procedure may be carried out in the maxilla, mandible, or both. Basically, this consists of the extraction of two premolars and the removal of a slot of bone as an extension of the socket, so that the tooth-bearing segment is mobilized and may be moved in a superior, inferior, anterior, or posterior direction (*Fig.* 1). The segment is then moved to the desired post-treatment position and retained by splints or bands and an archwire until union is complete.

Fig. 1.—The maxillary and mandibular osteotomy sections demonstrated on a skull. A, Lateral view. B, Anterior view. C, Palatal view.

Where no distal movement is required, for example to elevate or depress the lower anterior teeth in an axial direction, surgical division can be made between the first premolars and canines without the extraction of a premolar. In the

Presented at the meeting held on 11 December, 1967.

maxilla, canines may be removed instead of premolars should this have advantages in a particular case.

CLASS II, DIVISION 1 CASES

There are certain general advantages and disadvantages when this surgical method is the total means of treatment.

The Advantages are:—

1. Expediency—the splints are worn for only 6 weeks on average and perhaps, surprisingly, patients accept these very noticeable splints better than a less noticeable orthodontic appliance for a longer period of time; this is assuming that an orthodontic alternative is available. The speed with which treatment is effected is particularly attractive to older patients.

2. The results may be technically superior to results that could be obtained using simple orthodontic appliances, since the incisors can be moved bodily in a distal direction.

The Disadvantages are:—

1. The choice of teeth to be extracted is limited to first premolars or upper canines in some cases.

2. The amount of movement in a distal direction is limited to the width of the extracted teeth, although so far this has proved adequate.

3. Any defects in the occlusion in areas other than the anterior region are unchanged.

4. The labial segment itself must be accepted as it is, which may mean accepting some crowding or spacing of the teeth. The latter can be improved by division of the labial segment itself in the midline.

5. The over-development of the lower anterior dento-alveolar structures must be dealt with either by grinding the lower incisors or by performing an osteotomy in the lower incisor region to depress these teeth.

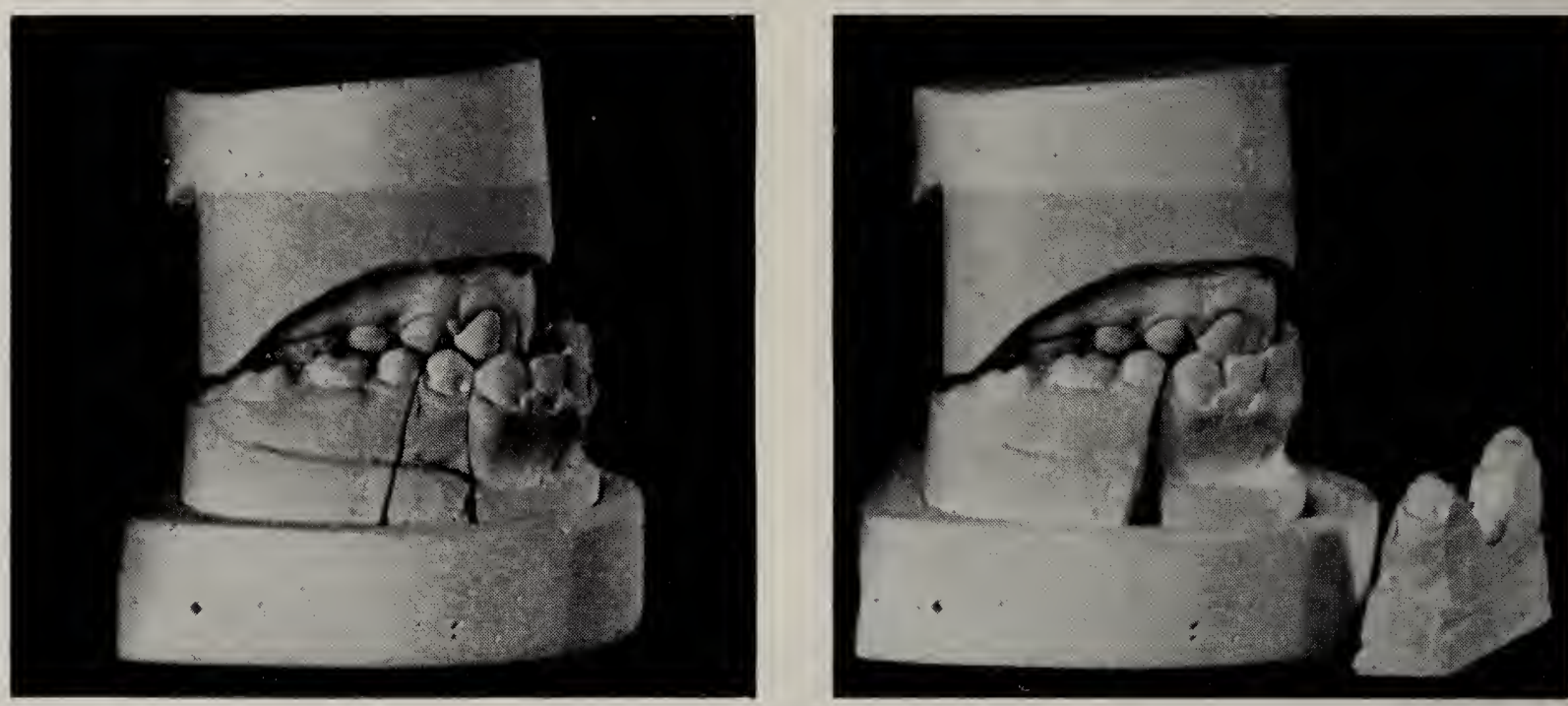
Some of the disadvantages disappear if simple orthodontic treatment is performed preoperatively. This may consist of one or more of the following steps:—

a. Depression of the lower incisors by means of a removable appliance with an anterior bite plane.

b. Buccal movement of the upper canines—this is often necessary because of the narrowing of the upper arch in the canine region. This generally goes unnoticed when treating a case orthodontically, because the canines are retracted into the greater arch width of the premolar region.

c. If the upper incisors are spaced, perhaps due to a now discontinued habit, the space can be closed by the use of an orthodontic appliance. This also has the advantage of restoring arch symmetry.

d. Another advantage of involving the orthodontist is that his assessment of the case may avoid the temptation to fit the patient to the operation, rather than the operation to the patient, a not unknown hazard of the past!



A B

Fig. 2.—Study models mounted on an articulator (not shown). A, Model sectioned. B, Section removed and the labial segment repositioned to simulate the operation.

Operative Planning

The desirability of orthodontic preparation and possible operative difficulties can be readily demonstrated by mounting a pair of study models on an articulator (*Fig.* 2). In the case of a maxillary procedure the upper model is mounted on the lower arm. The appropriate model is then sectioned and the operative movements simulated.

Case Reports

Case P. O'N.

This case illustrates the combination of orthodontics and surgery. This was the second case we treated surgically, and illustrates some of the problems and our mistakes.

This 12-year-old boy had a severe Class II, division 1 malocclusion on a Skeletal II base (*Fig.* 3 A). The lips were grossly incompetent and there had originally been a thumb-sucking habit. There was a tongue-to-lower-lip contact during swallowing, with a tooth-together swallow.

The lateral skull tracing before treatment (*Fig.* 4 A) shows the extreme proclination of the upper incisors and an SNA/SNB difference of 8°.

It was felt that complete reduction of the overjet should be attained in this case if a lip-to-lip adaptive behaviour was to be obtained, this being important for the stability of the end-result. Removable appliances could only have achieved this at the expense of extreme retroclination, and a fixed appliance was contra-indicated on the grounds of doubtful co-operation and oral hygiene.

It was, therefore, decided to retrocline the incisors as much as closure of the anterior spacing would

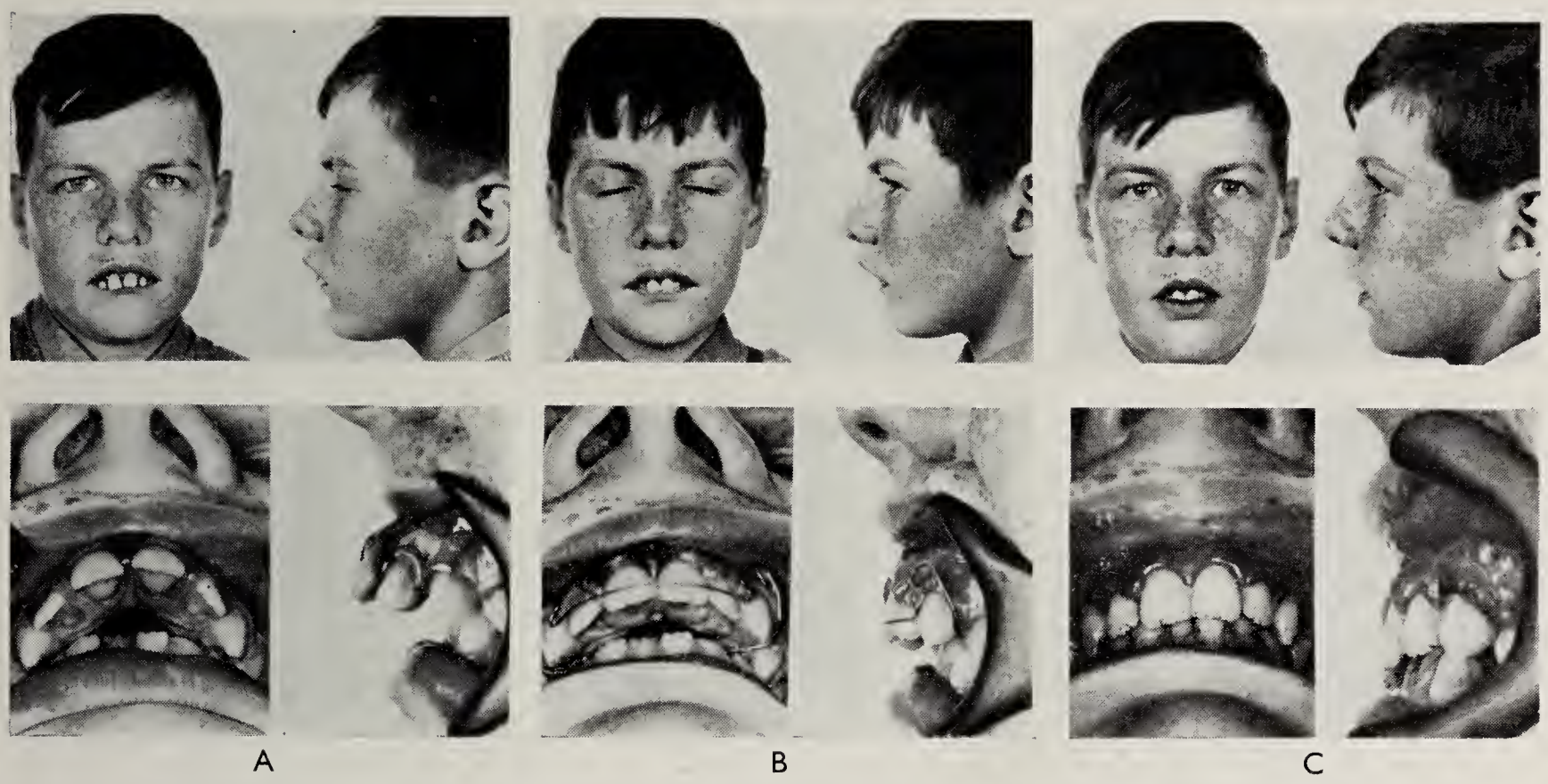


Fig. 3.—*Case P. O'N.* Clinical appearance. A, Before treatment. B, After presurgical orthodontic treatment. C, The final result 6 weeks after splint removal.

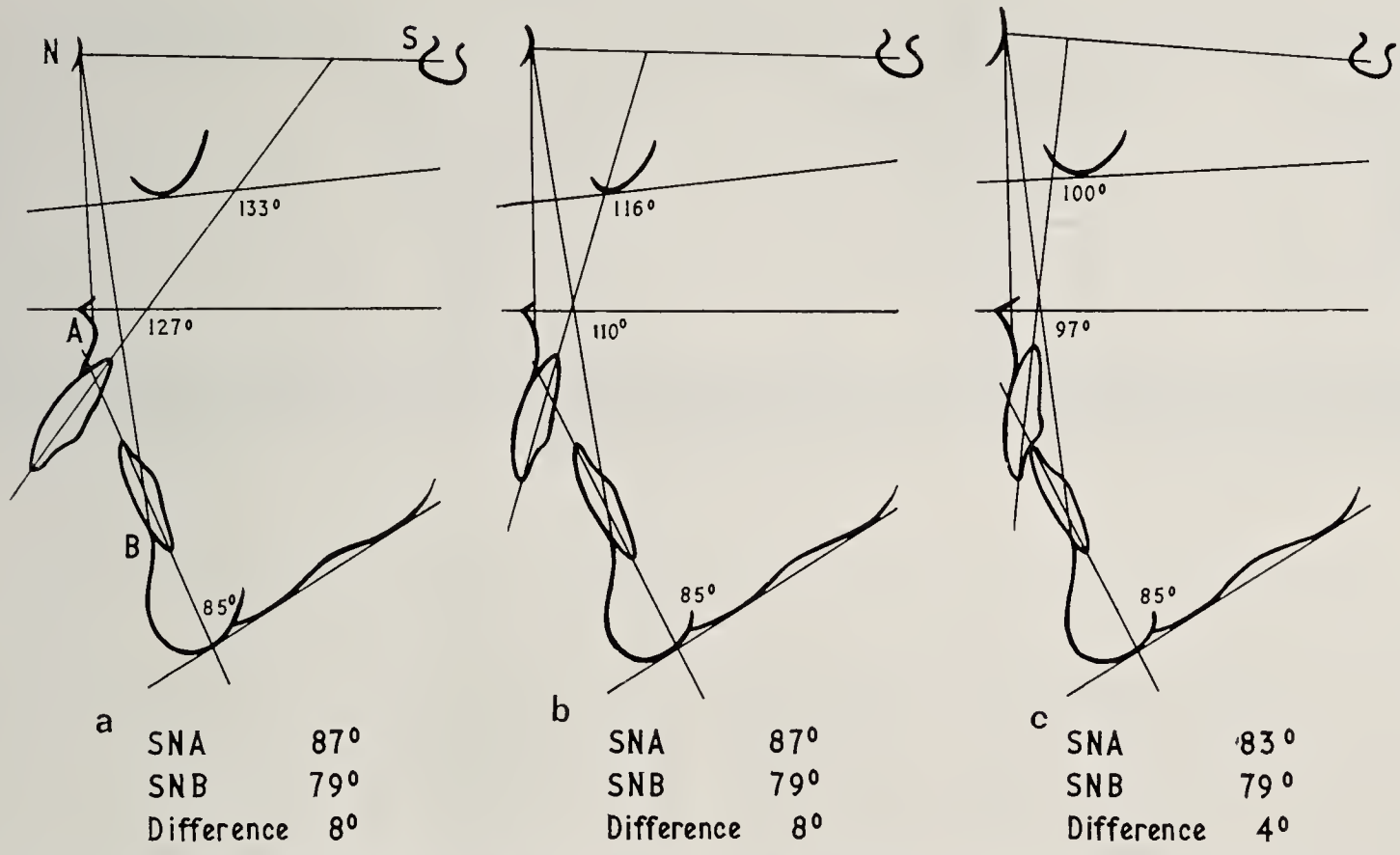


Fig. 4.—*Case P. O'N.* Lateral skull tracings corresponding to the clinical views in *Fig.* 3.

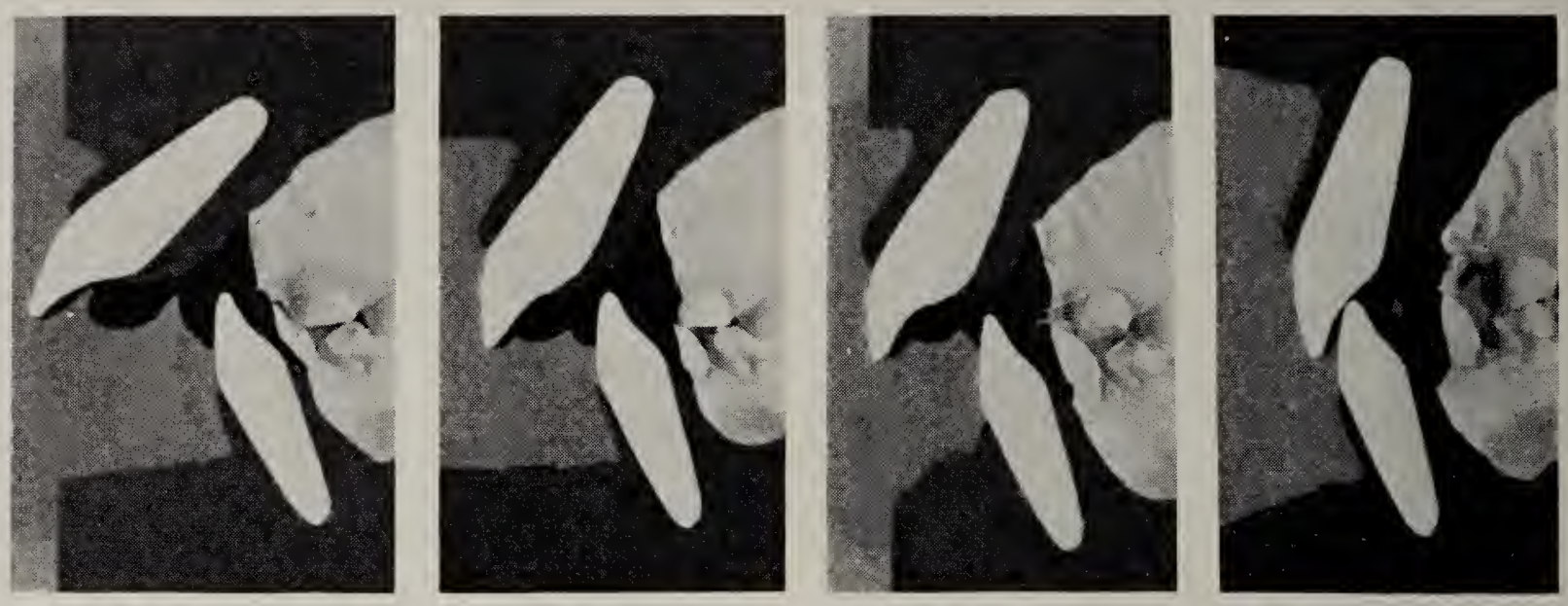
permit and then reduce the residual overjet surgically.

This orthodontic movement was achieved using a removable appliance with a Roberts' retractor, anchorage being reinforced by extra-oral traction. *Fig.* 3 B is the clinical appearance at the end of this stage.

All the anterior spacing has been closed and the upper incisor angulation is very near to the mean value (*Fig.* 4 B), although a large residual overjet remains. sectioned study models (*Fig.* 5 C) that depression was adequate and no further orthodontic preparation was required.

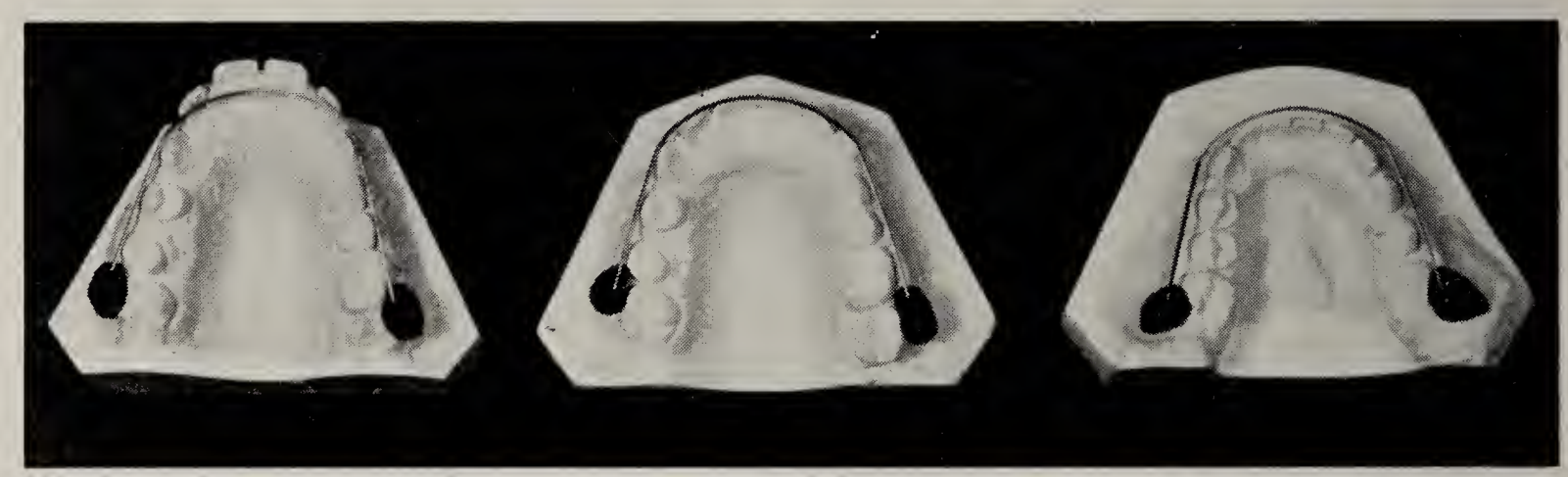
The operation was performed at this stage and 6 weeks later the splints were removed, the result being shown in *Fig.* 3 C. The overjet is completely reduced and the upper incisors are under the control of the lower lip.

The sectioned models (*Fig.* 5 D) show the final occlusion. Analysis of the postoperative tracing



A B C D

Fig. 5.—*Case P. O'N.* Study models sectioned through $\underline{1|}$. A, Before treatment. B, After incisor space closure. C, The same stage after lower incisor depression. D, The final result. (The root outline on the models was extrapolated using a template constructed from the lateral skull X-ray.)



A B C

Fig. 6.—*Case P. O'N.* Identical archwires superimposed over upper model. A, Before and B, After orthodontic treatment. C, Lower model demonstrating the restoration of coincident arch form.

This treatment phase also successfully restored coincident upper and lower arch form (*Fig.* 6). The sectioned study models (*Fig.* 5 B) show the extent of the orthodontic movement, and also that, despite the original incomplete overbite, there is still inadequate depression of the lower incisors to allow the upper labial segment to be moved bodily in a distal direction.

From the surgical aspect it is easier to move the segment in a purely distal direction, and orthodontically this is in accord with Parker (1964) who states that in the majority of Class II, division 1 cases depression of the upper incisors is not required and, in fact, is contra-indicated.

A removable orthodontic appliance with an anterior bite plane was worn for 3 months, and an analysis of the articulated models shows (*Fig.* 2 B), as do the (*Fig.* 4 C) shows the SNA value to have been reduced by 4°, but the upper incisors have been retroclined by 13°. This was not intended, and there are two possible explanations. Firstly, there may have been some laboratory inaccuracy. It has been pointed out by Mills (1962) that a lower incisor proclination of 10° may only mean 2 mm. linear movement at the incisal edge, and an error of this degree could easily go unnoticed. Secondly, if the splints and localizing bars were correct a bony spicule on the interface of the osteotomy slot could go unnoticed, the result being tilting of the segment and incomplete localization of the localizing bars.

Case R.R.

This 26-year-old married woman was referred by her general practitioner for treatment of her temporo-

mandibular joint pain. Examination showed her to have a severe Class II, division 1 malocclusion on a Skeletal II base (*Fig.* 7 A). The lips were potentially competent and the lower lip contracted behind the upper incisors, contacting the tongue, to produce an anterior oral seal, this being facilitated by the forward posturing of the mandible.

It was felt that this posturing forward together with some cuspal interference which prevented centric occlusion from being readily obtained, were the main aetiological factors for the joint pain.

The cuspal interference was readily corrected by selective occlusal grinding, but the reduction of the overjet to obviate the posture was more of a problem, since the patient at first rejected the idea of wearing any appliance that would show. The possibility of a surgical approach was discussed, and this was accepted owing to the rapidity with which the end-result could be obtained.

Examination of the articulated models showed that some increase of intercanine width, together with anterior space closure and slight lower incisor depression, was required. The desired movements were achieved in 4 months with a removable appliance, this being made as unobtrusive as possible to overcome the patient's initial reluctance to wearing such an appliance.

The osteotomy was then performed and the overjet was fully reduced (*Fig.* 7 B). The facial appearance and profile is little changed as would be expected in view of the potentially competent nature of the lips before treatment and the habitual forward mandibular posture which tended to disguise the malocclusion. However, an amelioration of the joint symptoms was achieved and this was the prime treatment objective.

The movement achieved by treatment is shown in the superimposed lateral skull tracing before and after treatment (*Fig.* 8).

A B

Fig. 7.—*Case R.R.* A, Before and B, After surgical repositioning of the upper labial segment.

	Pre-treatment	*Post-treatment*
SNA	83°	80°
SNB	79°	79°
Difference	4°	1°
$\underline{1\|1}$ to SN	118°	96°
$\underline{1\|1}$ to M.M.	126°	102·5° (calculated)
M.M. angle	27°	27°

Fig. 8.—*Case R.R.* Lateral skull tracing before and after treatment superimposed on NS.

These osteotomies have so far been considered essentially from the viewpoint of the oral surgeon, but the question remains as to whether we as orthodontists can advise the procedure as an extension of our normal technique.

The question can best be answered by considering some of the fundamentals of the Class II, division 1 malocclusion. The salient feature of

Fig. 9.—See text.

such a case is the increased overjet which may be due to proclination of the upper incisors, or the skeletal base separation of upper and lower incisors due to the skeletal base discrepancy, or most commonly it is a combination of the two in varying proportions. In our diagnosis we must determine the contribution of these factors. For the simplicity of description the fact that the lower incisors may be proclined or retroclined before treatment has been ignored.

If the overjet is mainly due to proclination, that is, a minimal base discrepancy, then the simple tipping action of removable appliances will prove to be adequate to reduce the overjet.

If the skeletal base discrepancy is the primary aetiological factor, the question is whether the maxilla or mandible is primarily at fault.

The patient shown in *Fig. 9* is a case where the mandible is at fault as evidenced by the restoration of facial profile when the patient is requested to posture forward to eliminate the overjet completely. Obviously, in this case any treatment in the maxilla, be it surgical or orthodontic, would be wrong and a surgical advancement of the mandible is indicated. Alternatively, growth stimulation by functional appliances would perhaps be advocated by some orthodontists.

When the skeletal discrepancy is due to the forward position of the maxilla there are several treatment possibilities depending on the treatment objectives, which should include stability and aesthetics. If the incisors have a relatively normal angulation before overjet reduction, a compromise solution is retroclination of the incisors beyond the mean value so that they are controlled by the lower lip, the residual overjet being accepted or eliminated by forward posturing. The situation can be helped in a small percentage of cases by the proclination of the lower incisors (Mills, 1966).

The ideal solution for these cases is bodily distal movement of the incisors to completely eliminate the overjet and preserve an overbite well within normal limits. The fully banded techniques, such as Begg or Edgewise, fulfil these requirements.

The problems with these techniques is the chairside time required and the absolute co-operation of the patient required in wearing auxiliaries such as elastics and in maintaining a high standard of oral hygiene.

It is for the group of cases that clinically require this type of treatment, but where co-operation is felt to be suspect or inadequate, that the surgical repositioning can be offered as an alternative. The results may not in technical detail compare with those treated by the Begg or Edgewise methods, but one of their basic objectives namely, bodily incisor movement, is achieved.

MILD CLASS III CASES

The orthodontic treatment of Class III cases is limited to those with a mild Skeletal III discrepancy, where there is an adequate degree of overbite. It consists of either proclination of the upper incisors or retroclination of the lower incisors, or a combination of the two. If there is an inadequate overbite after treatment, the case will relapse. The other problem is that if the lower incisors are out of muscle balance after treatment, but the overbite is adequate to maintain the new incisal relationship against this imbalance, a traumatic occlusion is then established (Hovell, 1966).

The surgical mobilization of the lower labial segment allows it to be moved vertically so that an overbite can be created and it can also be moved in a distal direction without excessive tilting. This requires qualification, since the amount of movement possible in this direction is determined by tongue size and position, a factor now recognized in major mandibular osteotomies when a tongue reduction may be required for a successful result (Hovell, 1966).

The surgical movement of the lower labial segment, therefore, applies to cases skeletally just a little more severe in an anteroposterior and vertical dimension than those treated orthodontically. It could be argued whether surgery is justified in such a mild skeletal discrepancy. The answer lies in the patient's request for facial improvement, since their appearance is often more prognathic than the anteroposterior skeletal discrepancy would have led one to expect. Although the height of the lower face due to a high Frankfurt-mandibular-plane angle may contribute something to this, the fullness and

slight eversion of the lower lip seems to be the main factor.

Ricketts (1964) and Williams (1965) have both stated that a harmonious facial profile results if the lower incisor tips are on or close to a plane drawn from ' A ' point to pogonion.

All our mild Class III cases that have been treated surgically have had lower incisors on average 5 mm. or more in front of this plane before treatment. The technical aim of the treatment has been to establish a Class I incisal relationship, but this has incidentally placed the lower incisor tips in close relationship to the A-Po plane. The postoperative result has provided an improved facial profile, and this appears to support the work of Ricketts and Williams.

Case Reports

Case S.I.

This 15-year-old girl was originally referred for orthodontic treatment with a view to improving function and appearance. She complained of her inability to incise hard foods and her prognathic appearance. Examination showed her to have a Class III malocclusion on a mild Skeletal III base with a high Frankfurt-mandibular-plane angle. There was an anterior open bite which was thought to be skeletal in origin. The lips were competent, and the tongue appeared to be of normal size. There was a tongue-to-lip contact during swallowing, but this was thought to be secondary to the open bite.

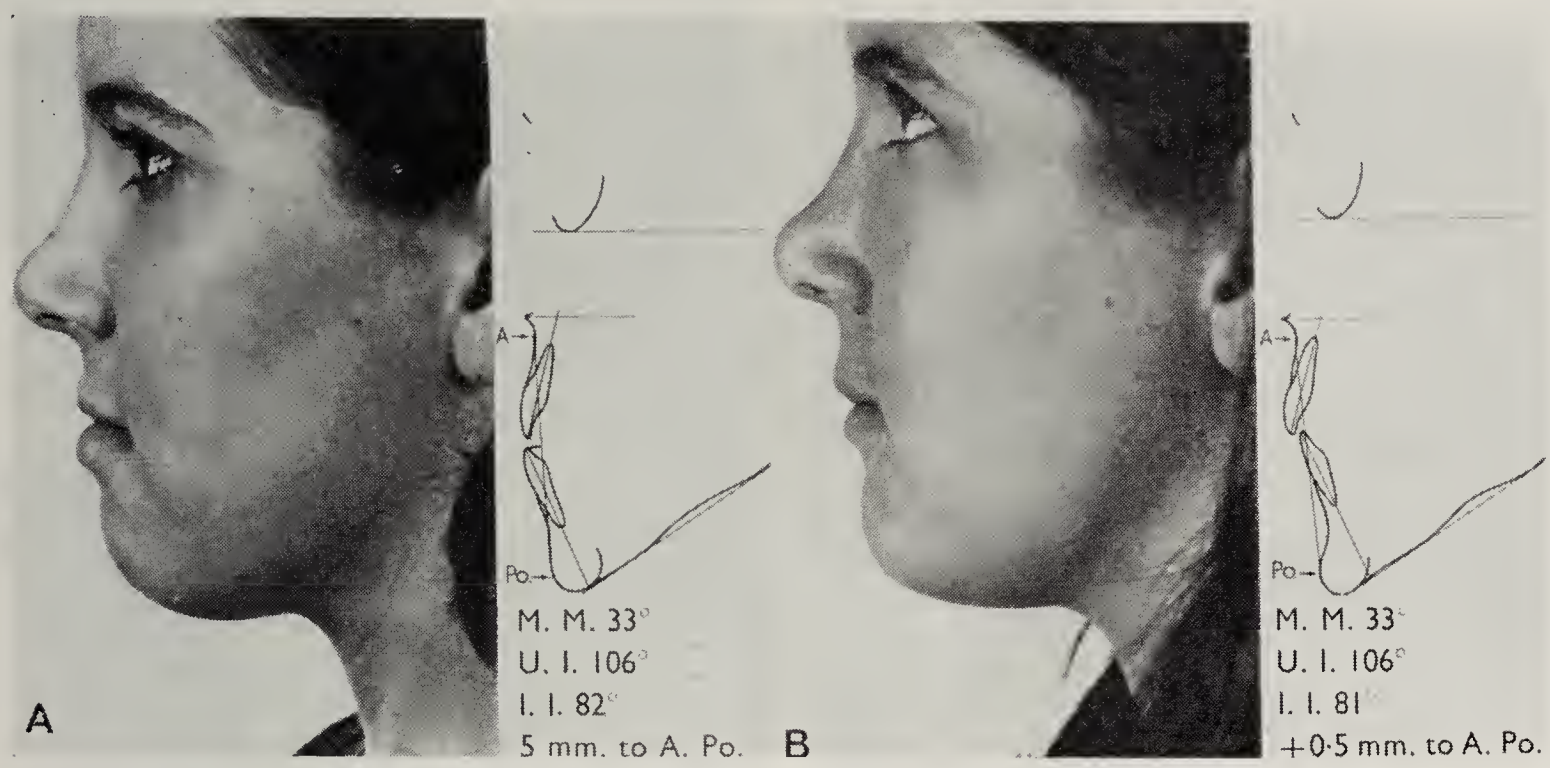


Fig. 10.—*Case S.I.* Profile and tracings. A, Before treatment. B, After treatment.

Fig. 11.—*Case S.I.* Lateral skull X-rays. A, Before treatment. B, Immediately after splint removed. C, Sixteen months later.

The prognathic appearance seemed to be due to two factors, namely, the high Frankfurt-mandibular-plane angle giving an increased facial height and the full everted appearance of the lower lip (*Fig.* 10 A). The skeletal discrepancy dictated a surgical approach

confined to the movement of the lower labial segment since the chin point seemed to be correct relative to the overall facial profile. The lower labial segment was moved superiorly and distally at the time of operation. In this case it was only necessary to extract $\overline{|4}$, since $\overline{4|}$ was already missing. The new position was maintained by a lower splint worn for 6 weeks.

The result is shown in *Fig.* 10 B, and the tracings show the improved relationship of the lower incisor

A B

Fig. 12.—*Case P.M.* A, Before and B, After treatment.

	Pre-treatment	*Post-treatment*
SNA	79°	79°
SNB	82°	78°
Difference	−3°	+1°
$\overline{1\|1}$ to M.P.	80°	83°
$\overline{1\|1}$ to A. Po	4 mm.	−1·5 mm.
M.M. angle	27°	27°

Fig. 13.—*Case P.M.* Lateral skull tracings before and after treatment superimposed on maxillary plane.

tip relative to the A-Po plane. The vertical movement obtained as measured along the plane from the lower incisor tip to nasion was 4 mm.

There has been a degree of relapse in the incisor relationship, but the result is now stable. A lateral skull tracing 16 months postoperatively shows the lower incisor tip to be 2·5 mm. in front of the A-Po plane and the overbite to have decreased by 1 mm. The overall changes are shown in the lateral skull X-rays (*Fig.* 11). This relapse suggests that the tongue activity may have been contributing to the open bite originally, and this case illustrates the difficulty of objectively estimating tongue activity.

Case P.M.

This 22-year-old patient complained of her prognathic appearance, and examination showed her to have a Class III malocclusion on a mild Skeletal III base, the Frankfurt-mandibular-plane angle being normal (*Fig.* 12 A). The prognathic appearance was felt to be primarily due to the lower lip contour.

There was a slight forward displacing activity when the patient closed into centric occlusion, but since the upper incisors were already proclined and the lower incisors retroclined, it was felt that orthodontic correction of the incisal relationship would probably create a traumatic occlusion

The surgical repositioning of the lower labial segment was, therefore, suggested and accepted; the

short overall treatment time being attractive to the patient. Models mounted on an articulator indicated that some increase of upper intercanine width was required to allow distal repositioning of the segment. This movement was achieved using a removable appliance which was worn for 3 months.

At this stage the operation was performed. $\overline{4|4}$ were extracted and as the X-ray tracings (*Fig.* 13) show the segment was repositioned distally with minimal tilting. The splints were removed and the final result is shown in *Fig.* 12 B.

CLASS II, DIVISION 2 CASES

These cases are a problem whatever treatment method is employed and we have not as yet treated such a case by surgery. Ballard (1967) has expressed the view that in some Class II, division 2 cases it might be possible to take the upper labial segment away from the influence of the lower lip and put it wholly against the upper lip with a permanent reduction in excessive overbite.

The surgical mobilization of the labial segment allows it to be readily depressed, and if both upper and lower segments are mobilized to alter the interincisal angulation the criteria for success should be readily met, and this application of the surgery warrants further investigation.

SURGICAL TECHNIQUE

The surgical technique in both the maxilla and mandible was illustrated at the December Meeting by two operative films. These procedures have been described previously (Henry and Wreakes, 1966) and to avoid unnecessary repetition, only a brief résumé will be included in this paper.

Surgical Approach Maxilla

In the maxilla it has been our custom to perform a two-stage operation with an interval of 2 weeks between each stage. At the first-stage operation a palatal flap is raised, and is so designed (*Fig.* 14) that the incisive foramen and anterior palatal vessels are left undisturbed, and the blood-supply of the labial segment thus insured.

Following the extraction of the two premolars and the removal of the predetermined amount of palatal bone, the mucoperiosteal flap is returned, sutured into position, and a retention plate, which is often the previous orthodontic appliance, is inserted. This serves the dual purpose of holding the flap in place and protecting it from trauma in the healing phase.

Immediately before the second operation, the upper three-part cast metal cap-splint is cemented and the lower splint, which has been fabricated, is tried on. We no longer cement this splint, as we have found that with meticulous preoperative planning, there has been no necessity to relocalize the locking plates and therefore no need for intermaxillary fixation.

Two weeks after the first operation, and 24 hours after splint cementation, the buccal approach is made (*Fig.* 15). The line of incision and type of flap raised is self evident, but it is important to make the approach so that the mucoperiosteum of the lateral wall of the nose can be identified and a submucosal dissection carried out. Instrumentation in these manœuvres is a matter of choice, but the author has found that surgical fissure burs, held in a straight handpiece with water coolant, to be perfectly satisfactory. With care, neither the mucosa of the floor of the nose or the antral cavity need be perforated, but, in the event, no trouble seems to result.

Having removed the requisite segment of bone on the buccal aspects, it is necessary to divide the septum from its vomerine attachment. It is easily approached via an incision in the labial fraenum, when the nasal spine can be identified. By the use of scissors, osteotome, or McIndoe's bone-cutting forceps, a submucous division or resection can be carried out.

At this stage the labial segment will be mobile and capable of reduction, which may be incomplete at first because of bony interference on the interfaces, particularly in the region of the lateral wall of nose. Any such bony spurs can be nibbled away, until the locking plates can be correctly located, when it becomes apparent that precise reduction has been obtained.

Once the locking plates have been screwed home and the labial segment fully immobilized, the soft-tissue wounds in the buccal sulcus are repaired and the patient returned to the ward.

Neither of these two operative procedures should take longer than 40 minutes and the time spent in hospital not more than 5 to 6 days. Six weeks after the second operation the locking plates are removed and the segment tested for union, which is usually found to be firm and in which case the splints are removed.

Surgical Approach Mandible

The general assessment of the patient and the preoperative planning are essentially the same as for the maxillary procedure, except that it is a one-stage procedure.

A prefabricated sectional cast metal cap-splint is cemented prior to operation at which time the appropriate teeth, usually $\overline{4|4}$, are removed if necessary.

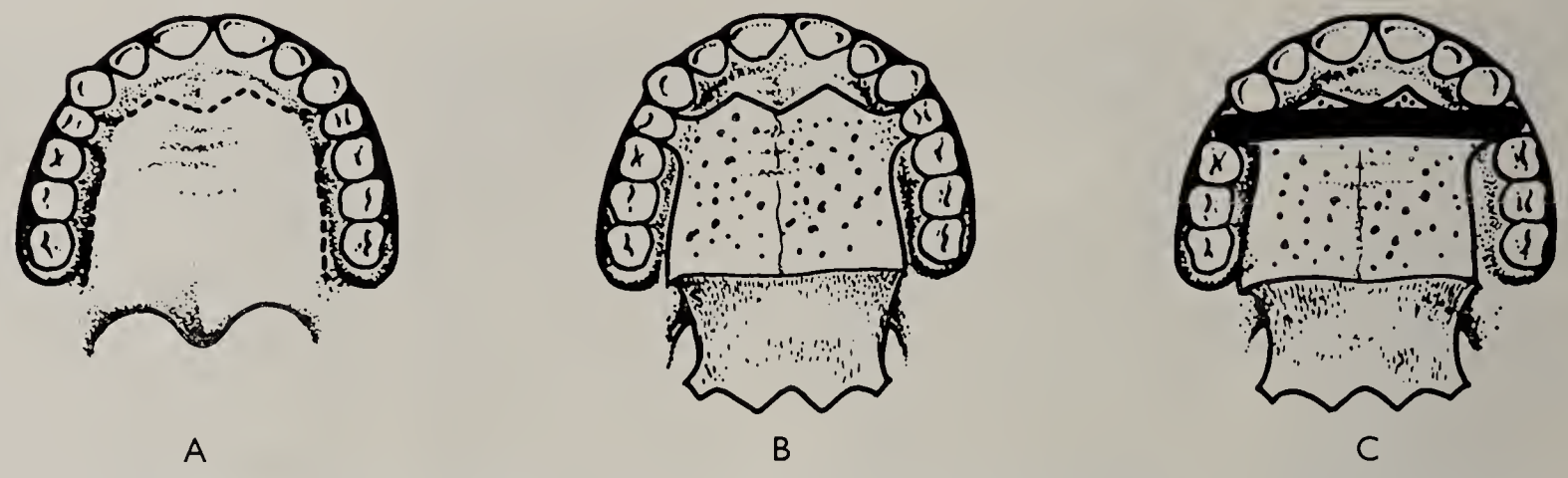
An incision (*Fig.* 16) is made and a large mucoperiosteal flap reflected, having first identified the mental foramina and nerves which can be left undamaged. The buccal walls of the sockets are now removed to their full depth, which provides a useful guide to the position of the $\overline{3|3}$ apices so that the horizontal osteotomy can be completed well below this region. In a non-extraction

case, the division is initiated between $\overline{5\ 3|3\ 5}$ using a fine tapered bur and completed with an osteotome.

Instrumentation, as previously, is a matter of choice, but it is only by experience that one senses the approach of the lingual plate, which is best fractured by a very thin broad-bladed osteotome. At this stage the labial segment will be mobile, but not infrequently irreducible due to interference at the lingual aspect of the $\overline{4|4}$ sockets, where visibility is lessened.

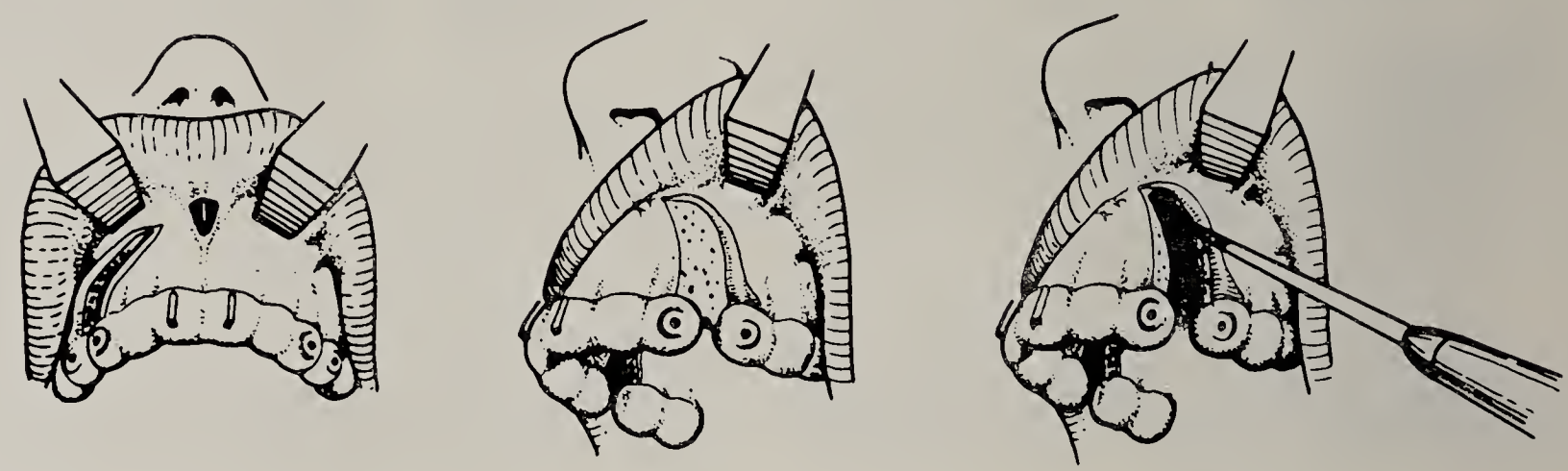
As in the maxilla, an attempt at reduction is made and under direct vision any encroaching bone spicules or slender shelves are removed until full reduction is obtained, as judged by the accurate fixation of the locking bars.

It is important that the integrity of the blood-supply to this quite sizeable block of tooth-bearing bone is maintained, and to facilitate this any subperiosteal elevation and retraction on the lingual aspect should be kept to a minimum.



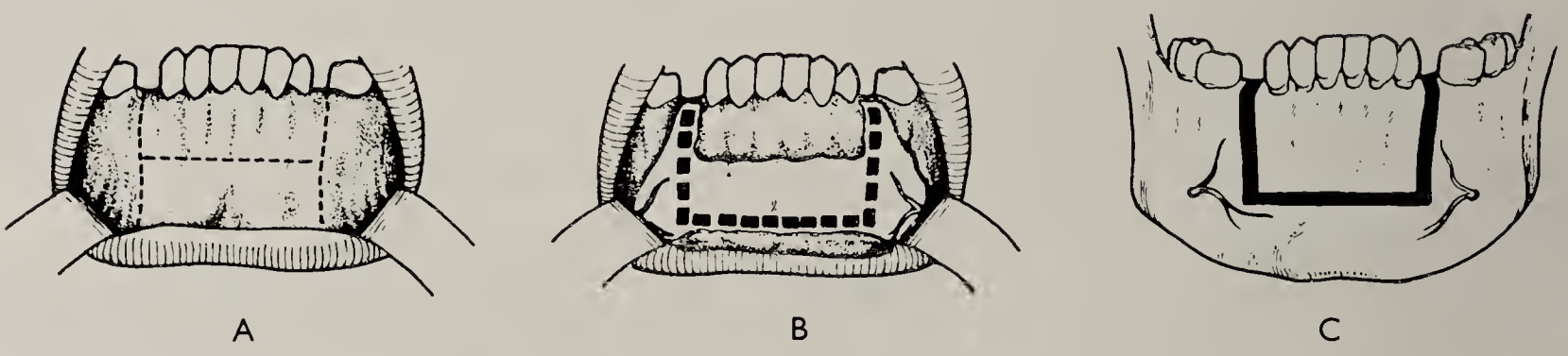
A B C

Fig. 14.—Maxillary osteotomy Stage I. A, Line of incision. B, Flap reflected. C, Palatal osteotomy cut. (*Reproduced from Archer, W. H.* (1966), '*Oral Surgery*'. *London: Saunders.*)



A B C

Fig. 15.—Maxillary osteotomy Stage II. A, Incisions for the buccal osteotomy cut and section of the septum. B, Buccal flap reflected. C, Bone removed. (*Reproduced from Archer, W. H.* (1966), '*Oral Surgery*'. *London: Saunders.*)



A B C

Fig. 16.—Mandibular osteotomy. A, Incision. B, Flap reflected. C, Osteotomy cut.

By the same token, when dividing and/or trimming the lingual wall of the sockets, the mucoperiosteum must be protected against accidental trauma, and in this respect, a Mac-Donalds dissector has proved invaluable.

Precise reduction having been achieved, judged by the application of the locking bars in their predetermined position, it is only necessary to close the soft tissues.

However, should the labial segment have to be moved, not only in an anterior or posterior

direction, but also elevated to correct an open bite, then a gap will be created between the sectioned surfaces. In these cases, it has been the authors' custom to fill the space that so exists by osteogenic material of an autogenous nature as this expedites new bone formation and union.

It must be realized that this procedure is not in the conventional sense a bone-graft, despite the fact that the iliac crest is the donor. The method employed is adequately described (Flint, 1964) and involves no more than a 1-in. incision over the crest and the removal of $\frac{1}{2}$ in. of cortical bone. Thereafter, using a sharp curette, a sufficiency of cancellous 'mush' can be removed from the interior of the ilium to make good the defect and provide osteogenesis, with eventually full bony union. The scar is minimal, there is no loss of contour, and there is no inhibition in walking, as opposed to the conventional bone-grafts taken from the inner table where complications and postoperative disability are far from unknown.

Finally, the soft tissues in the buccal sulcus are repaired in the normal manner, and endotracheal tube withdrawn and the patient returned to the ward, where the hospitalization should only be a matter of 3 or 4 days.

There are, however, some general comments which can well be made concerning these procedures, which the authors feel offer advantage to the patient and surgeon.

In the maxillary osteotomy, there has been published and not infrequently performed, a one-stage procedure. There are two disadvantages to this method.

1. As the palatal mucoperiosteum is undermined laterally, leaving an anterior and posterior attachment, visibility is poor and precise removal of palatal bone in the midline is not possible.

2. Despite the fact that the anterior palatal attachment is intact, it is not unknown for the labial segment to have its blood-supply put in jeopardy at the time of the buccal approach.

On the other hand, it must be admitted that the two-stage operation, whilst offering a considerable safety factor, involves two anaesthetics and two admissions to hospital, but the first operation is so trivial that it can almost pass in the way of simple extractions and does not detain the patient for any length of time.

Anaesthesia is of great importance and the comparatively recent advances that have been made in hypotension have facilitated these operations, not only by reducing the operative bleeding but in minimizing haematoma formation subsequently.

In this respect, the administration of Chymar (a proteolytic enzyme), particularly at the second-stage maxillary procedure, has exerted a profound influence in minimizing postoperative oedema, so the swelling of the upper lip and cheek is quite slight and bears no resemblance to the oedema that can confidently be expected in some less major procedures.

The short time spent in hospital is also an added advantage, being at the most, a total of 7 days for the two maxillary stages and somewhat less for the mandible.

On the other hand, the wearing of a cap-splint, even on one jaw, alone, can be of some slight embarrassment, but as 6–8 weeks is the maximum period of retention, this compares more than favourably with the two cap-splints and intermaxillary fixation of 12-weeks' duration usually adopted for a mandibular ostectomy.

SUMMARY

The surgical movement of the labial segment may be indicated on clinical grounds or by virtue of circumstances. The latter is particularly true for older patients for whom expediency often takes precedence over the fact that the method is surgical. All cases should ideally be assessed orthodontically before any treatment is planned.

Our experience suggests that the splint fabrication must be performed with extreme precision if the desired result is to be obtained, and bony interference on the interface of the osteotomy cut must not be allowed to prevent the segment being fully located in the desired position.

Acknowledgements

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DISCUSSION

Dr. J. R. E. Mills, opening the discussion, said that what had impressed him most was the great amount of time and care taken, before the surgery was carried out, in planning the operation. It seemed to him that this was where they had won before they even went into the surgery, by spending a great deal of time.

The authors had mentioned a number of points, but perhaps one of the most important points they had made they had never mentioned, and that was the collaboration between the oral surgeon and the orthodontist. He was sure that this was something that had to be learnt in both specialties and which had been demonstrated during the presentation.

For years, there had been massive jaw resections, particularly of the mandible. They were major operations, not without snags and not even without tragedies, and it seemed to him that these local resections perhaps had a wider application, for example, in the Class II, division 1 type of case. This appealed to him particularly, because experience of maxillary fracture would seem to show rapid union, and very few went wrong.

A point on which Mr. Wreakes had touched concerned canines. Usually, not always, with a Class II, division 1 malocclusion, there was overjet on the central and lateral incisors, but not the canines. Mr. Wreakes said that they had to be moved labially. He wondered if Mr. Wreakes had had any trouble with canines tending to drop into cross-bite—he personally had seen this happen.

So far as lower resections were concerned, the speakers were to be congratulated very much on the choice of cases, but he thought they were rather exceptional cases. It was rather unusual to find the alveolus more prominent than the chin point. These cases had worked very well. So often in these cases, the chin point was more prominent than the alveolus, the teeth leant lingually and the alveolus was set back on the chin, and what the patient complained of was the chin point.

He was not in a position to comment on the surgery, but there were one or two things he wondered about. One was, was there any anaesthetic effect, any anaesthesia of the teeth or the overlying areas. If so, was it permanent and did it matter?

He also wondered why there was oral intubation in the second operation, in the Class II, division 1 cases.

There were one or two orthodontic points he wished to raise with Mr. Wreakes. Mr. Wreakes said that the Andresen appliance might be used to bring forward the mandible. He was interested in this and wondered if Mr. Wreakes knew of any evidence that this could, in fact, be done to any clinically worthwhile extent, because there had been a number of papers that claimed to show it, but it was usually an order of a millimetre or so.

He was interested, also, that Mr. Wreakes considered that bodily lingual movement of the upper incisor apices could only be carried out by proponents of the edgewise and Begg religions. If Mr. Wreakes cared to look at the Transactions of the Society in the current and next issue, he would find much simpler methods of doing this.

Mr. J. H. Gardiner asked whether, in the follow-up experience of reducing the prominence of a lower labial segment, the speakers had had experience of having to reduce the tongue? If so, in what proportion of cases had this to be done?

Mr. J. W. Softley asked a supplementary question to the last one. If the tongue was reduced, what were the criteria for deciding on the reduction.

His second question concerned the last slide shown. He thought that there was an incomplete overbite originally and wondered if this was so. Postoperatively, the teeth were, he noticed, in contact. In other words, had the tongue adapted itself to the new incisor relationship.

Mr. B. Scheer asked what happened to the vitality of the incisor teeth subsequent to the operation.

Colonel E. S. Foster asked in the two-stage operation on the maxilla whether the gap of 15 days was critical and whether any difficulty was experienced in repositioning due to bony spicules or due to the fibrous tissue forming in the prepared space.

Mr. D. H. Oliver asked what proportion of consent was obtained from people undergoing these very major operations. He had mentioned it to one or two of his patients, telling them what a delightful treat there was in store for him at the meeting, and some of them expressed considerable horror at the thought. He therefore wondered what percentage of consent was obtained.

Mr. Cradock Henry, taking first of all anaesthesia of the teeth, admitted that, after surgery, for a variable length of time, sometimes 6 weeks to 3 months, the involved teeth appeared to be temporarily denervated. He thought that the nerve-supply had been temporarily interrupted. His feeling was that if these teeth were non-vital to the extent that they had no blood-supply, then probably the blood-supply of the whole block of bone would have to be involved, and there was no evidence of this. On an electric pulp tester, return was up to 75 to 100 per cent as a comparison with the preoperative readings. He thought there was probably insufficient detail available, of the innervation, particularly of the lower incisors. It was debatable whether there were not, in fact, some fibres in the seventh nerve which might be involved—sensory fibres as opposed to purely motor fibres. None of the teeth had changed in colour at all, so there was no suggestion of interrupting the blood-supply.

The reason for oral intubation at the second stage was that, in performing the buccal osteotomy, one was infringing on to the nasal space by elevating back the nasal mucoperiosteum because it was a submucous resection in this region and the space occupied by the tube would be too great; so the first-stage procedure was performed by nasal intubation and the second stage by oral intubation. It was purely a mechanical reason.

On the thorny question of tongue reduction, admittedly in the ordinary run of severe Class III cases where one had to do an osteotomy, a large proportion had to have tongue reduction. Of that there was no doubt. In one mild Class III case that had been done, he thought that it had been a mistake not to do a tongue reduction. This was the girl who was filmed who showed a slight degree of relapse towards her original anterior open bite, suggesting tongue activity as an aetiological element in addition to the skeletal factor. Tongue reduction may have facilitated favourable adaptation to the altered anatomical environment postoperatively in this case.

With regard to the gap of time between the first- and second-stage operation, this was a purely arbitrary period of time that was chosen in the sense that it was felt that 15 days would allow the palatal flap to be fully healed—in other words, it was being retained almost like a pedicle to ensure the vitality of that labial segment however much interference one did buccally afterwards. That was felt to be the minimum period of time that could be allowed. It had always been 15 days until a recent case where, owing to various vicissitudes, there was a delay of 21 or 23 days between the two stages. The difference in the operative procedure was simply enormous. Very tenacious, very hard fibrous tissue had formed in the socket and to an extent, down the palatal osteotomy, and it was very difficult to scrape it off and very difficult to reduce the segment. It was something they had not come across in cases where a 15-day gap had been allowed.

With regard to the spicules of bone, having completed the osteotomy and taken out the requisite section of bone, the relative segments are pushed towards the predetermined position. If, however, when the predetermined locking bars are applied, they cannot be fully located, it usually means that there are some bony spicules on the interface preventing full reduction. Commonly, these are to be found in the maxilla in the region of the lateral nasal wall and in the mandible on the lingual aspect of the premolar sockets. He felt that knowing the sites where this interference commonly occurred saved much in the way of trial and error, not to mention time and temper in the theatre!

On the question of consent to operations, he realized that the filmed operation might at first sight look alarming, but he deprecated these procedures being called ' major '. In the majority of cases, that was untrue. There were many, many wisdom teeth extractions which were much more difficult operative procedures to do than any of these and if you could persuade a patient into having a wisdom tooth out, you could certainly persuade them into having this procedure done.

Mr. Wreakes said that the first point raised was in respect of the canines. He stressed the importance of moving the segment posteriorly bodily. Technically this was the easiest thing to do and it maintained the vertical relationship of canines. Perhaps the problem mentioned that the canine slipped back palatally after preoperative buccal movement was due to adverse rotation of the labial segment, as this would take the canines into a position of infra-occlusion thereby removing the stability of normal cuspal interdigitation.

He thought he had chosen his words carefully and felt that if he said that for the patient with the Class II, division 1 malocclusion where the mandible was at fault, that the ideal treatment was a surgical one, someone would get up and say they could stimulate the growth to achieve the same thing! He would not attempt this approach and had put the comment in for the sake of completeness.

In choosing the words ' fixed appliance technique for bodily movement such as Begg or edgewise ', he thought he had again picked his words carefully. He had been tempted to include the technique described by Parker, but was stuck for a short description, unless he called it the ' Parker technique '.

On the question of anaesthesia and vitality, one of the difficulties was that when electric stimulation was normally used, one was in the fortunate position of being able to compare vitality response with teeth on the opposite side in the same jaw, but when there was nothing but the opposing jaw to judge by, this might not be a valid record. Recently, there was an article in the *British Dental Journal* by Mumford, which pointed out that one should not draw conclusions from vitality responses and showed histological evidence why one should not necessarily expect a normal response to be correlated with a normal histological pulp appearance.

Another point was that the vitality response was not necessarily synonymous with blood-supply, and it was reasonable to suppose that the flaps retaining the segment did ensure adequate blood-supply to the teeth, perhaps through the periodontal membrane.

Mr. Softley had asked about the second Class II, division 1 case shown. This was a very odd occlusion because again this patient had temporomandibular joint problems and had a number of ' centric bite ' positions.

Mr. Softley was correct in surmising that there was an incomplete overbite before treatment. This was associated with a tongue-to-lip contact to create an anterior seal, but fortunately the activity had been discontinued subsequent to overjet reduction.

FRICTIONAL FORCES IN FIXED ORTHODONTIC APPLIANCES

J. NICOLLS, L.D.S., D.Orth. R.C.S.

FIXED appliances offer many advantages over removable. More complicated tooth movements can be performed and results are generally more rapid and precise. Nevertheless, if friction develops between the tubes, brackets, or elastics and the arch wire, movement may be slowed down or even halted; or in some cases undesired movements accomplished. A good example would be a case in which an upper first premolar has been extracted and the canine is being moved distally along the arch wire. The canine carries a band with a simple ' ripple ' bracket (made with the Russell bracket-making machine) (*Fig.* 1 A). Movement is being accomplished with elastic intramaxillary traction. This traction will cause the canine to start tilting distally. This it will do until the arch wire comes into contact with the upper edge of the bracket slot anteriorly and the lower edge posteriorly (*Fig.* 1 B). Friction will then start to develop. This will mean that less of the force is now available to move the canine. If sufficient force is still available, there may be a further small amount of tilting, which will cause the arch wire to bend slightly (*Fig.* 1 C). This will increase the friction, and the bent arch wire will endeavour to straighten and so exert a torque which will tend to move the apex distally. Thus only bodily movement will now be possible; which of course requires more force than does tilting and so puts a greater strain on anchorage.

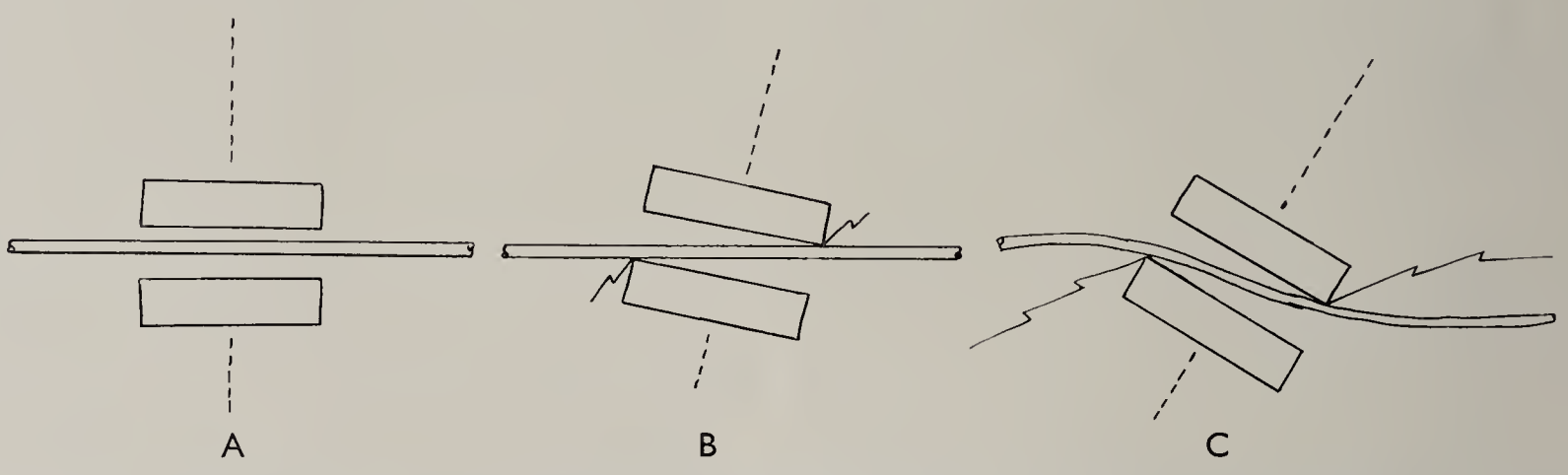

Fig. 1.—A, Unless the ligature is tight there is negligible friction. B, After the tooth has tilted a certain amount of friction is generated. C, With further tilting there is greater friction.

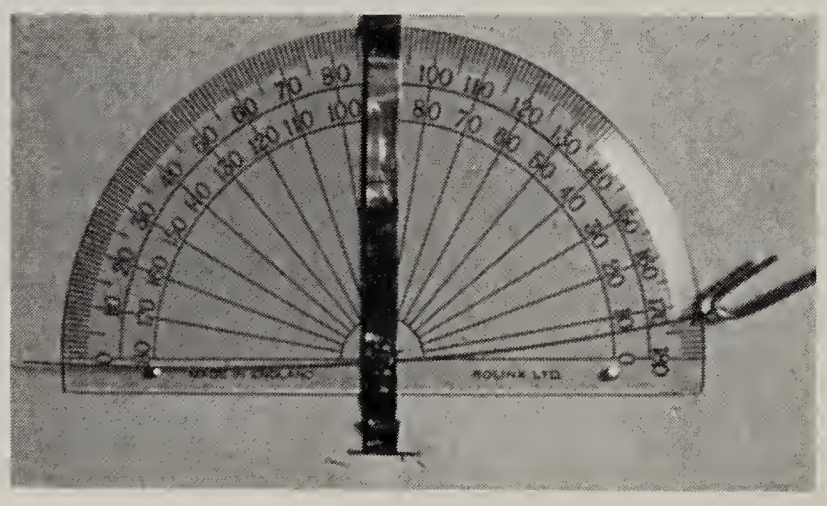

Fig. 2.—Method 1.

METHODS

Method 1 (*Fig.* 2)

A geometrical protractor was mounted on a white card, supported on a firm wooden base. A ' ripple ' bracket, 2·5 mm. wide, was welded to a length of band material, and, by stapling the tape to the wooden base, the bracket was positioned horizontally with its right-hand edge at the centre of the protractor. A piece of 0·016 in. high-tensile wire was ligated to the bracket and the right-hand end of the wire was attached to a dynamometer. Force was applied through the dynamometer until the wire commenced to slide through the bracket. The value of the force needed to start movement was recorded for various angles of wire to bracket. Obviously, the angle of the wire *in* the bracket can only be increased up to the point at which the wire touches the lower edge of the bracket on the left and the upper edge on the right or vice versa. If one attempts to increase the angle, the wire

Presented at the meeting held on 8 January, 1968.

outside the bracket will bend. Because of this bend, the reading ' angle of wire to bracket ' will depend on the distance away from the bracket at which the reading is taken. The edge of the protractor used was 50 mm. away from the bracket, and this was considered to be too far away to be in any way comparable to conditions found in the mouth. A distance of 10 mm. away from the bracket was arbitrarily decided on for measuring the angle. At this distance there is a loss of accuracy in measurement. This, however, was not considered to be of great significance, as measurement of a similar angle on an appliance in the mouth would be even more difficult to measure accurately. The experiment was repeated using brackets 2·0 mm. and 1·5 mm. wide, and with a welded ' sheath ' (for details *see* Method 2), and also with a 0·7 mm. length of 0·9-mm. I.D. tube soldered to band material.

A further test was done with the 2·5-mm. bracket and twin 0·25-mm. wires (' Johnson twin ').

Method 2

A typodont was used. A band carrying a welded ' sheath ' was placed on the lower right first molar tooth. The sheath was made from 5·0 × 0·125-mm. tape, pressed on the Russell machine. This results in a tube which will pass a piece of 0·6-mm. wire freely but not 0·7 mm. The sheath was in the horizontal plane and the 0·016-in. wire, which was inserted through the sheath, was also kept in the same plane. An elastic band was hooked over the distal end of the wire and pulled in the direction of the upper canine to simulate the use of elastic for intermaxillary traction (*Fig.* 3 A). One dynamometer was attached to the elastic and another to the distal end of the wire. Different tensions were applied to the elastic, and for each the force required to cause the wire to commence sliding was measured. This was carried out with two types of elastic band, viz., (1) ordinary office bands of the type extensively used for orthodontics, and (2) the special latex band made for

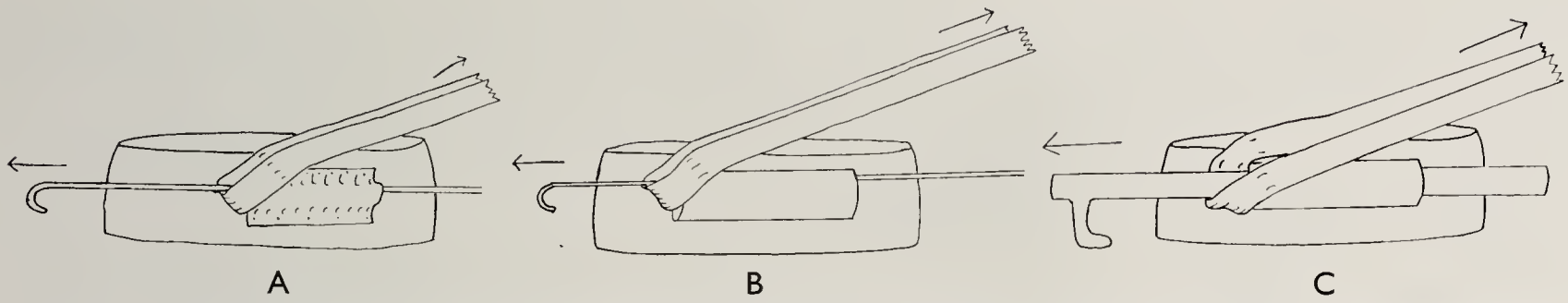

Fig. 3.—Measurement of friction generated when intermaxillary elastics are used. A, With welded sheath. B, With soldered tube. C, With the Johnson twin wire appliance.

Table I.—Friction developed between Arch Wires and ' Ripple ' Brackets

		Arch Wire			
		0·016 *in. High Tensile*			*Twin* 0·25 *mm.*
Width of Bracket		2·5 mm.	2·0 mm.	1·5 mm.	2·5 mm.
Angle of Arch Wire to Bracket	0°	(oz.) 0	(oz.) 0	(oz.) 0	(oz.) 0
	5°	0	0	0	0
	7°	1 –1½	0	0	0 – ½
	10°	2½–4	0	0	½–1½
	12°	3 –7	½	0	½–1¾
	15°	5 –9	6	0	½–2
	20°			3	1 –2½
	22°			6	1¼–2¾
	25°				2 –3½

orthodontic use. The experiment was repeated with a 7·0-mm. length of 0·9-mm. I.D. tube soldered to the molar band (*Fig.* 3 B) and then again using the soldered tube, but replacing the wire with the 0·5-mm. I.D. ' end-tube ' as used in the Johnson twin wire appliance (*Fig.* 3 C).

Table II.—Friction developed between Molar Tubes and Arch Wires

Angle of Wire to Tube	0·016-in. Arch Wire	
	7·0-mm. Tube 0·9-mm. I.D. Soldered	*5·0-mm. Sheath Welded*
	(oz.)	(oz.)
0°	0	0
5°	0	0
10°	$\frac{1}{2}$	$\frac{1}{4}$
15°	$\frac{3}{4}$	$1\frac{1}{4}$
20°	$1\frac{1}{4}$	2
25°	$1\frac{1}{2}$	3
30°	2	
35°	$2\frac{1}{4}$	

Table III.—Friction developed between 0·016-in. Arch Wire and Elastic Bands

Tension on Elastic	7·0-mm. Tube 0·9-mm. I.D. Soldered		50-mm. Sheath Welded	
	Office Elastic	*Latex Elastic*	*Office Elastic*	*Latex Elastic*
(oz.)	(oz.)	(oz.)	(oz.)	(oz.)
2	1 –$1\frac{1}{2}$	0–$\frac{1}{4}$	1	$1\frac{1}{4}$
3	$1\frac{1}{4}$–2	0–$\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{1}{2}$
4	$1\frac{3}{4}$–$2\frac{1}{2}$	$\frac{1}{2}$–1	$2\frac{1}{2}$	2
5	$2\frac{1}{2}$–3	$\frac{1}{2}$–$2\frac{1}{2}$	$2\frac{3}{4}$	$2\frac{1}{4}$

Method 3

A typodont was again used with a molar band carrying a soldered 0·9-mm. I.D. tube. A ' Johnson end-tube ' with soldered hook was inserted in the molar tube, and using an elastic band attached to the hook at one end and to the dynamometer at the other, the end-tube was drawn back through the molar tube. The force required to draw the end-tube was measured and the angle subtended by the elastic band to the end tube was varied.

RESULTS

The results of Method 1 are shown in *Tables I* and *II.*

The results of Method 2 are shown in *Tables III* and *IV.*

Table IV.—Friction between 0·9-mm. ' End-tubes ' and Elastic Bands (Molar Tubes 7·0-mm. Soldered)

Tension on Elastic	Office Elastic	Latex Elastic
(oz.)	(oz.)	(oz.)
1	$1\frac{1}{2}$–$3\frac{1}{4}$	4–6
2	2 –5	6–8
3	3 –$5\frac{1}{2}$	6–9
4	5 –6	6–9

In Method 3 it was found that, up to an angle of 30°, friction was negligible, *provided there were no burs or distortions on either of the tubes.*

OBSERVATIONS

Ligating

The arch wires were ligated to the brackets with 0·25-mm. soft wire. It was found possible to cause friction from a tightly-tied ligature. The amount of this friction was very variable, although an effort was made to tie all ligatures with approximately equal tightness. The friction developed was from 0 to 7 oz. with 0·016-in. wire and 2·5-mm. brackets, and with the same brackets and twin 0·25-mm. wires it was $3\frac{1}{2}$ to $4\frac{1}{2}$ oz. It was observed that once the wire had moved a little through the bracket friction became negligible. Presumably the movement bent the ligature wire away from the arch wire slightly. For the experiment all ligatures were first tied tightly and then loosened by passing a fine-pointed probe underneath. This effectively reduced friction from the ligature to a negligible value.

Bracket Friction

As would be expected, a narrower bracket allows a greater degree of tilt before it begins to bind. Nevertheless, when, with the narrower bracket, binding does start, it occurs suddenly and severely.

Tube Friction

The figures with the 0·9-mm. I.D. tube showed considerable variation under apparently identical circumstances. Those for the sheath were more consistent. Average values are given. It will be

appreciated why it is easier to move lower second molars forward if they are uprighted first.

Elastic Friction

These figures suggest that the practice of hooking the elastics round the projecting ends of the arch wire can greatly reduce the effectiveness of inter- or intra-traction. With 0·016-in. wire, latex elastics offer some advantage over office ones. With the Johnson twin appliance, elastic friction assumes formidable proportions, and, surprisingly, is greater with the latex elastics.

Tilting

If we assume that the average canine tooth tilts about a point 20 mm. above the centre of the bracket; then, if we start with the root of this tooth perpendicular to the arch wire, geometrical construction will show that with a 2·5-mm. bracket, the crown can move approximately 2·5 mm. before bracket friction occurs. For a 2·0-mm. bracket, it can move 4·0 mm., and, with a 1·5-mm. bracket, the distance will be 7·0 mm. (about one ' unit '). For a premolar, assuming 15 mm. from the point of rotation to bracket, the figures are 1·8 mm., 3·0 mm., and 5·0 mm. respectively.

Bodily Movement

If bodily movement is desired, a wider bracket is preferable. If this is done with intramaxillary elastics, and the remaining teeth are prevented from moving along the arch, then a more powerful elastic may be used. The extra force will be dissipated in overcoming the friction and will not add to the strain on anchorage.

Table V.—Friction between 0·9-mm. I.D. Tubes (Soldered) and 0·016-in. Wire

Angle of Wire to Tube	Tube Burnished	Loop Bent in Wire	Loop plus Burnished Tube
	(oz.)	(oz.)	(oz.)
0–10°	0	0	0
15°	$\frac{1}{4}$	0	0
20°	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$
25°	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{2}$
30°	1	1	$\frac{3}{4}$
35°	$2\frac{1}{2}$	$1\frac{1}{4}$	1

Intermaxillary Traction

When Class II mechanics are being used, the effects of friction must be considered in both upper and lower appliances. Let us take as an example a Class II, division 1 case, where all four first premolars have been extracted and the upper canines are being moved distally along the arch, by elastics, to a multiband lower appliance. If appreciable friction occurs in the upper canine brackets, the lower anchor teeth will be called on to move the canines bodily. Furthermore, because of the canine bracket friction, the upper arch wire will tend to move with the canines, thus causing the lower anchor teeth to also move the central and lateral incisors. If there are stops in front of the upper first molars, the anchorage will be pitted against them also. Consider the lower appliance. Traction from the elastics will cause the lower first molars and the second premolars to tilt, with consequent friction in their brackets. This will tend to push the lower arch wire forward, and if this happens proclination of the lower labial segment will result.

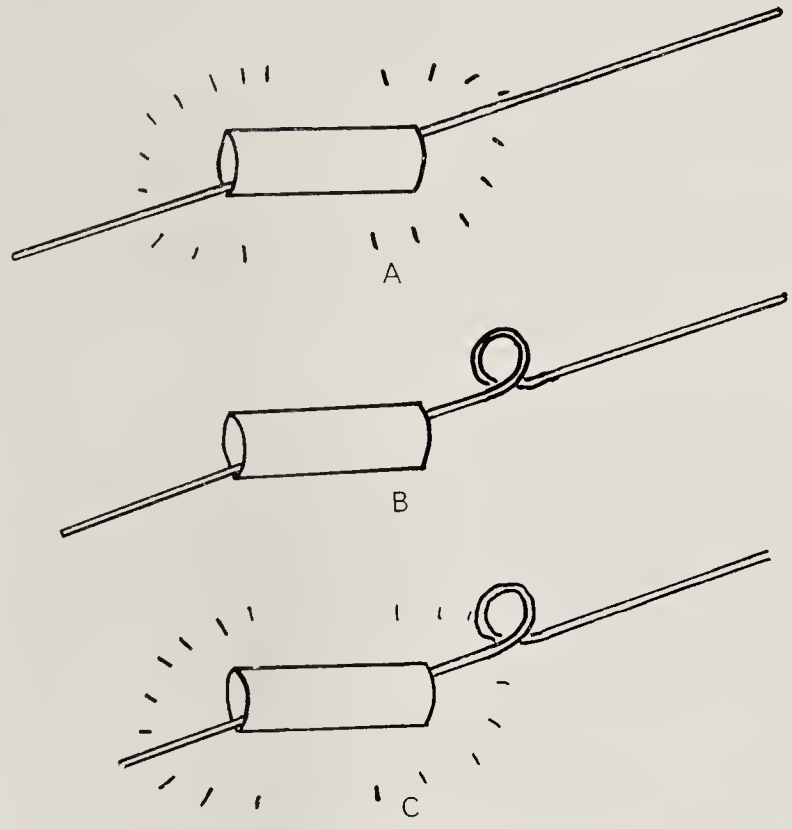

Fig. 4.—Friction may be reduced by: A, Burnishing the ends of the tube; B, Bending a loop in the wire; C, A combination of A and B.

REMEDIES

Friction of arch wire, or end-tube, against elastic bands may obviously be overcome by the simple expedient of having the molar tubes sufficiently long, distally, to allow the elastic to be hooked round the tube and not the arch wire. Alternatively, a hook may be provided for attaching the elastic.

If it is desired to move a tooth along the arch wire and tilting is permissible, it might sometimes be an advantage to use a narrow bracket. The initial inclination of the tooth and the amount of movement desired must be considered; and it should be remembered that when, with a narrow bracket, friction does occur,

it may amount to nearly a ' seize up '. If cost does not preclude it, a ribbon arch bracket is ideal. If lightly pinned, an unlimited amount of tilting can occur. This, of course, is the basis of the Begg technique.

It was noticed that, after the wire had slid through the tube or bracket a few times, friction became much less. Doubtless this was because the edges became burnished. It was also noticed that the friction values with twin 0·25-mm. wires were lower than single 0·016-in. wires. Possibly this was due to the greater flexibility. Therefore a further experiment was carried out to test those possibilities (*Fig.* 4). Method 1 was used, with 0·9-mm. tubes (7·0 mm. in length) and 0·016-in. wire. A tube, with the ends burnished, was used with a straight wire and then an unburnished tube was used, with a wire which had a simple small round loop bent into it, to increase flexibility. Finally, the wire with the loop was used with the burnished tube. Results are shown in *Table V*. This shows that burnishing is of value and suggests that, if other considerations do not preclude it, the use of a loop, or a U-bend, to increase flexibility will further reduce friction.

SUMMARY

Undesirable frictional forces may occur between the components of fixed orthodontic appliances. These forces have been measured under bench conditions and their implications in treatment considered. In all the examples given, it would be reasonable to suppose that there would be some reduction of friction under mouth conditions, because of the lubricating effect of saliva.

DISCUSSION

Mr. F. Allan said that Mr. Nicolls was quite right about the friction. The thicker the arch wire the greater the friction became. All fixed appliances were based on arch wires on the whole and if one got away from the arch wire, which was a necessary evil, it ought to be possible to get into a non-friction system.

There were non-friction systems whereby there could be movement without any friction at all.

Dr. J. R. E. Mills said Mr. Nicolls had brought out an extremely important point in the question of sliding brackets or tubes along arch wires. Things could be improved by narrowing the bracket, but, even with this, the tooth would eventually jam, and Mr. Nicolls had shown that when this occurred, it did so suddenly. He felt that the practice of sliding teeth along arch wires, whether the Eastman ripple bracket or the edgewise bracket was used, was very dangerous.

The better way to move teeth distally was with some means whereby the arch wire got shorter—in other words, a loop between the two points that had to be moved so that, in fact, both ends of the wire were stationary in the bracket and did not have to slide through.

Mr. Nicolls said that he used closing loops frequently for that reason.

A STUDY OF A PAIR OF TWINS TREATED BY INTERMAXILLARY TRACTION

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HEREDITY is said to play a large part in the aetiology of malocclusion. For this reason the incidence of the various types of malocclusion in monozygotic and dizygotic twins is of interest. Lundström (1960) stated:—

'The relative importance of genetic factors on the one hand and internal and true environmental factors on the other may be estimated for the various properties of the occlusion by observation on twins. Dissimilarities between identical twins are due to differences in environment, whereas dissimilarities between fraternal twins having genetic differences such as are displayed by siblings are due to differences in both environment and heredity.'

A B

Fig. 1.—Photographs of Christine. A, Before treatment. B, After treatment.

A B

Fig. 2.—Photographs of Coral. A, Before treatment. B, After treatment.

Monozygotic twins with dissimilar malocclusions were reported by Leech (1955, 1957). This

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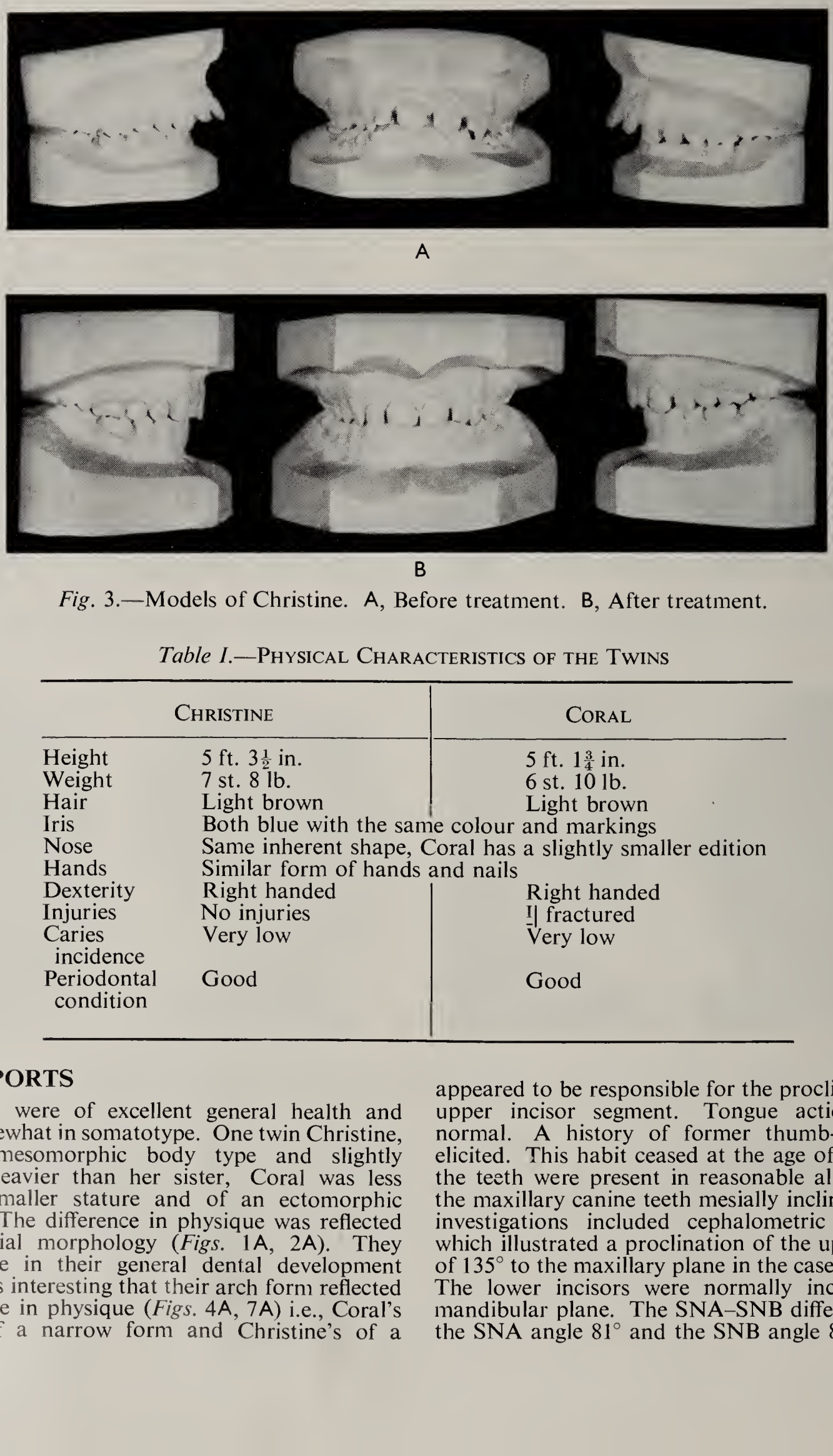
report concerns a pair of presumed dizygotic twins with similar malocclusions in a dissimilar dentofacial environment, and their response to the same form of treatment. Treatment for both twins consisted of fixed intermaxillary traction over a period of 12 months, and the report includes an analysis of the results attained.

broader type. An examination was made of the various features of each twin and the results correlated (*Table I*). Christine and Coral presented for treatment at age 12 years 11 months.

Christine presented a Class II, division 1 malocclusion on a Skeletal III base (*Figs.* 3A, 4A). The lips were potentially competent, being separated by the upper labial segment. Excessive mentalis activity



A

B

Fig. 3.—Models of Christine. A, Before treatment. B, After treatment.

Table I.—Physical Characteristics of the Twins

	Christine	Coral
Height	5 ft. $3\frac{1}{2}$ in.	5 ft. $1\frac{3}{4}$ in.
Weight	7 st. 8 lb.	6 st. 10 lb.
Hair	Light brown	Light brown
Iris	Both blue with the same colour and markings	
Nose	Same inherent shape, Coral has a slightly smaller edition	
Hands	Similar form of hands and nails	
Dexterity	Right handed	Right handed
Injuries	No injuries	$\underline{\underline{1}}$| fractured
Caries incidence	Very low	Very low
Periodontal condition	Good	Good

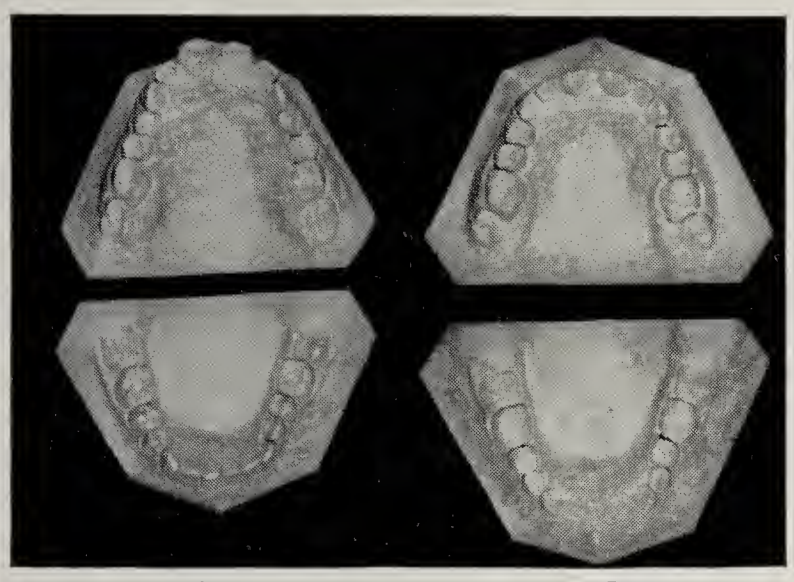
CASE REPORTS

Both girls were of excellent general health and differed somewhat in somatotype. One twin Christine, was of a mesomorphic body type and slightly taller and heavier than her sister, Coral was less heavy, of smaller stature and of an ectomorphic body type. The difference in physique was reflected in their facial morphology (*Figs.* 1A, 2A). They differed little in their general dental development although it is interesting that their arch form reflected the difference in physique (*Figs.* 4A, 7A) i.e., Coral's arch was of a narrow form and Christine's of a

appeared to be responsible for the proclination of the upper incisor segment. Tongue action appeared normal. A history of former thumb-sucking was elicited. This habit ceased at the age of 8 years. All the teeth were present in reasonable alinement with the maxillary canine teeth mesially inclined. Routine investigations included cephalometric radiography which illustrated a proclination of the upper incisors, of 135° to the maxillary plane in the case of Christine. The lower incisors were normally inclined to the mandibular plane. The SNA–SNB difference was 1°, the SNA angle 81° and the SNB angle 80° (*Fig.* 5A).

Coral (*Figs.* 6A, 7A), presented with a Class II, division 1 malocclusion on a Skeletal II base. The SNA angle was 85·5° and the SNB angle 81°. The upper incisors were proclined at 128° to the maxillary plane and the lower incisors 100° to the mandibular plane (*Fig.* 8A).

Incompetent lips with an attempt at a lip seal during swallowing was a feature of the activity of the anterior oral musculature. A thumb-sucking habit was present up to the age of 8 years.

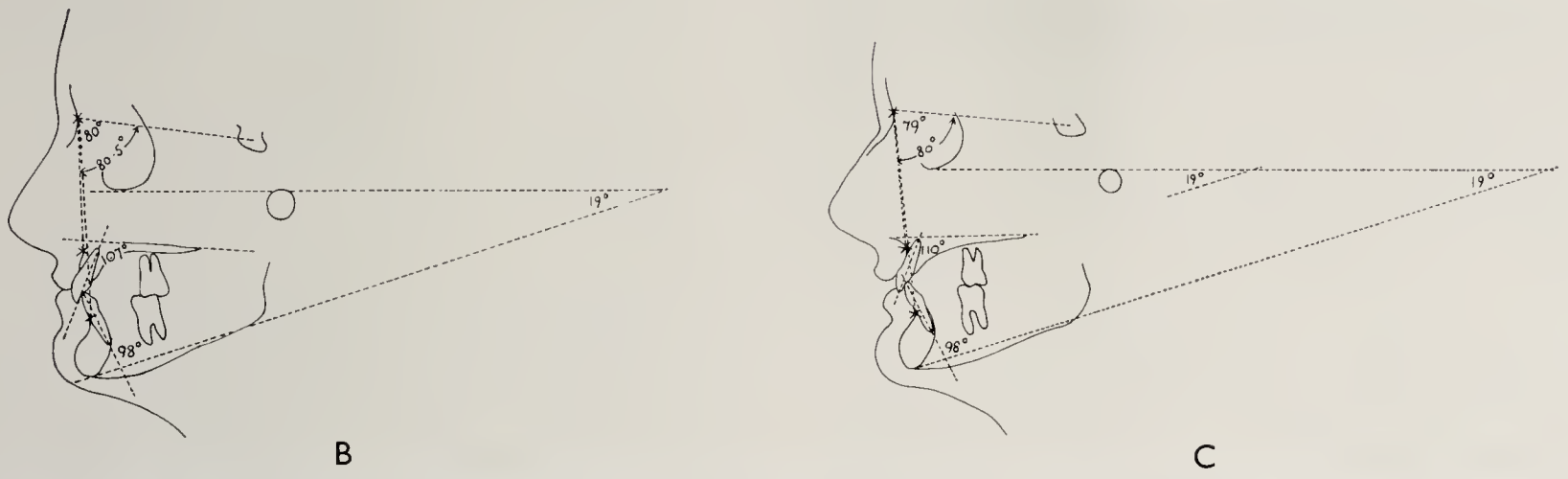


A B

Fig. 4.—Occlusal views of Christine's models. A, Before treatment. B, After treatment.

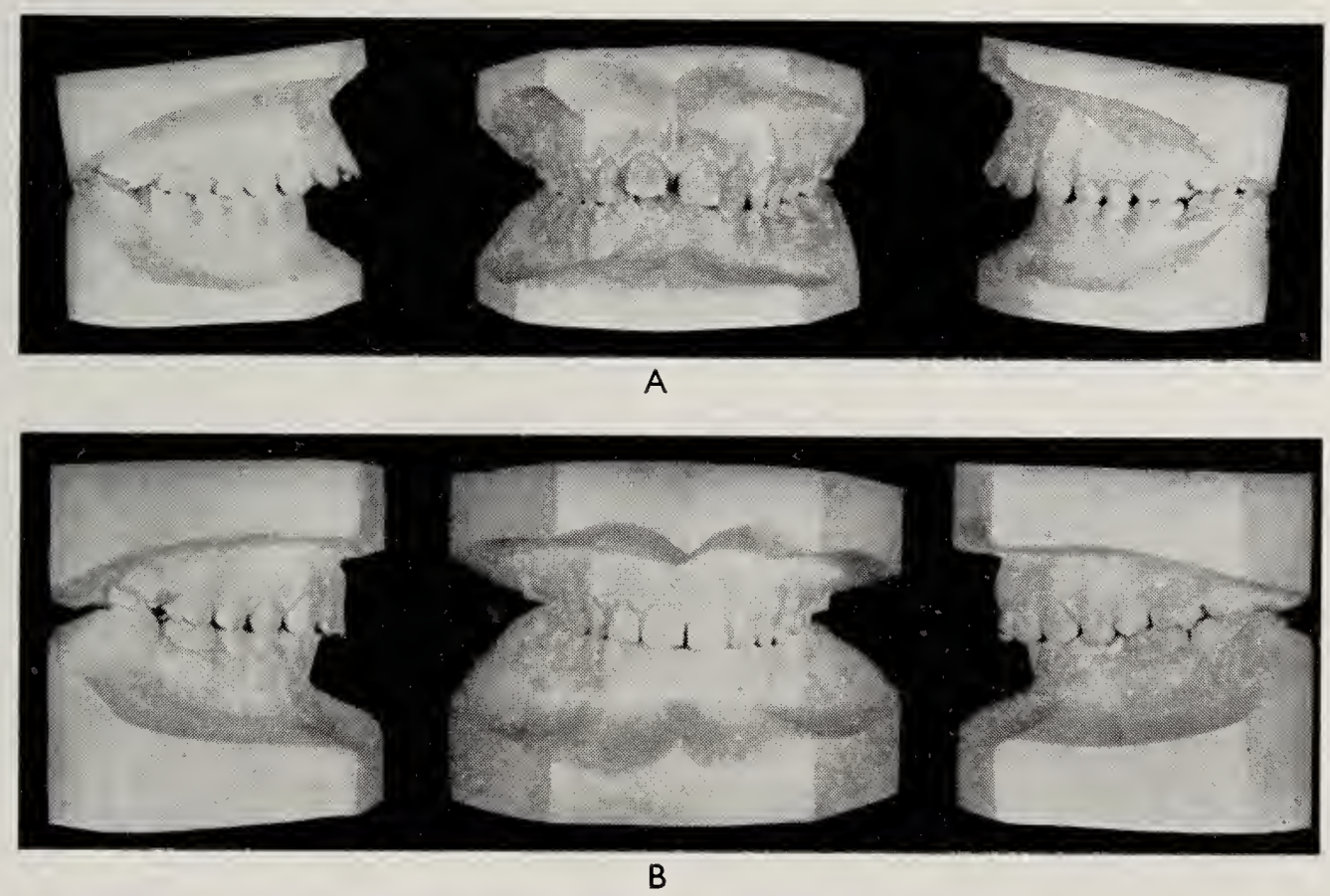
Treatment

In view of the good basal bone the treatment of choice was to restore correct occlusion without



A B C

Fig. 5.—Lateral skull radiographs of Christine. A, Before treatment. B, After treatment. C, Five months out of retention.



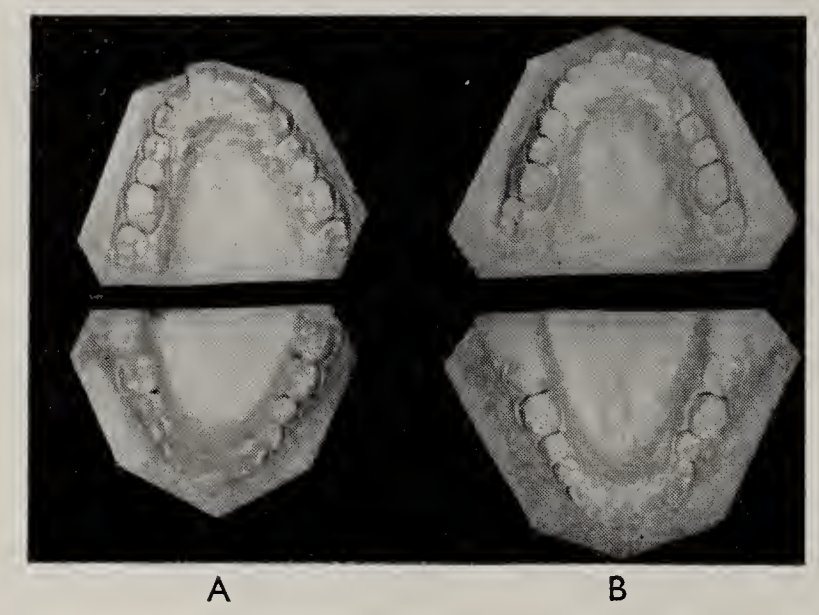
A B

Fig. 6.—Models of Coral. A, Before treatment. B, After treatment.

recourse to extractions. It was felt that if correction of the buccal segment occlusion proved to be difficult or if the lower incisors began to procline excessively then the maxillary second molars would become the teeth of choice to extract.

Fixed appliances were constructed for both children to carry out plain intermaxillary traction. These consisted of bands on the upper and lower first permanent molars with a short palatal arch incorporated in the upper appliance and a lingual arch in the lower appliance. A free-sliding labial arch was constructed in the upper appliance in tubes attached to the upper molar bands. Hooks were constructed on the free-sliding labial bow in the premolar regions and also on the disto-buccal corners of the lower molar bands. Stops were added to the labial bow mesial to the buccal tubes on the upper molars as distal movement of the upper teeth was required.

The appliances were fitted on 29 August, 1965. No. 6 elastics were applied initially and were changed to No. 4 elastics in the case of Christine on 23 March, 1966, and in the case of Coral on 16 November, 1965. The reduction in overjet was as shown in *Table III*.



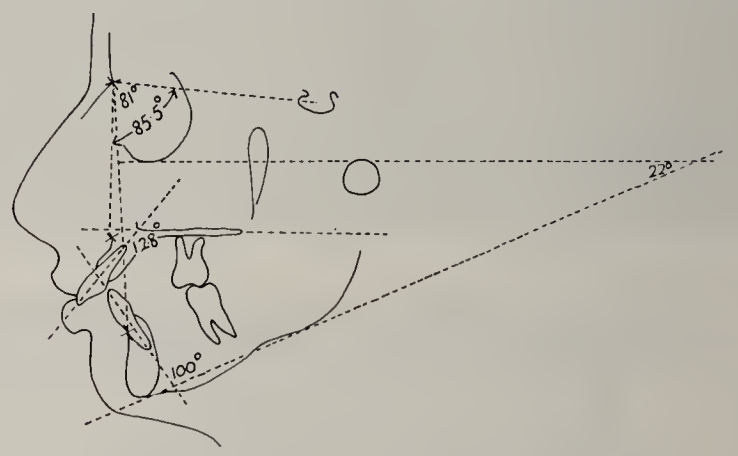
A B

Fig. 7.—Occlusal view of Coral's models. A, Before treatment. B, After treatment.

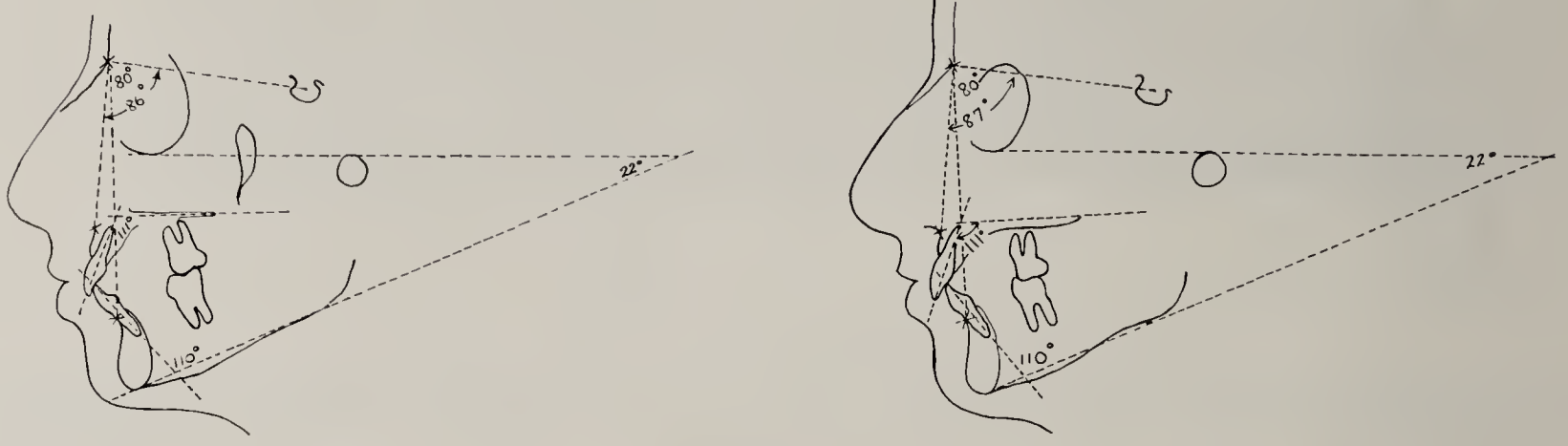
Results

A cephalometric appraisal of the final result, demonstrated in the case of Christine, that the upper incisors had been retroclined 28° and the lower incisors proclined 8°. The apical base was in the same relationship (*Fig.* 5B). The anterior oral seal was very much improved and an improvement in the facial profile was affected (*Fig.* 1B).

In the case of Coral the upper incisors had been retroclined 17° and the lower incisors proclined 10°.



A



B C

Fig. 8.—Lateral skull radiographs of Coral. A, Before treatment. B, After treatment. C, Five months out of retention.

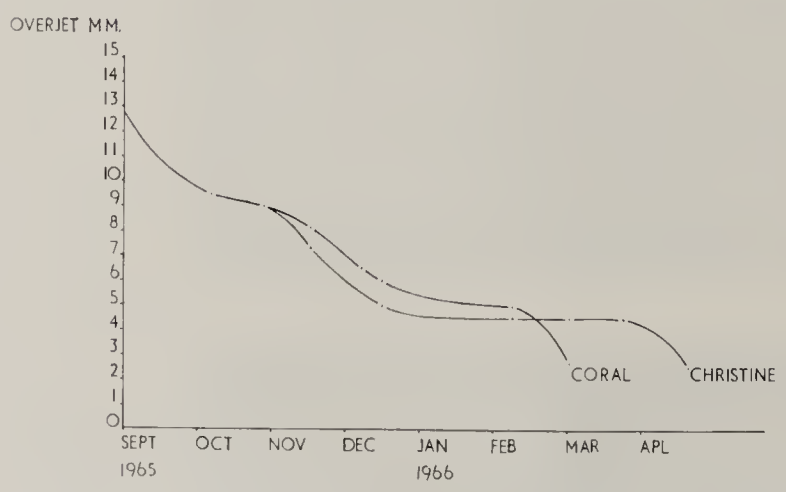


Fig. 9.—Graphs to show the reduction of overjet in the two girls.

Table II.—Skeletal Characteristics

	Christine		Coral	
	Before	*After*	*Before*	*After*
SNA	81·0°	80·5°	85·5°	86·0°
SNB	80·0°	80·0°	81·0°	80·0°
Inc./Max. Pl.	135·0°	107·0°	128·0°	111·0°
Inc./Mand. Pl.	90·0°	98·0°	100·0°	110·0°

The apical base was unaltered (*Fig.* 8B). The mola relationship had been corrected to a Class I relationship (*Fig.* 6B). The anterior oral seal was very much improved and again a more pleasing facial profile was attained (*Fig.* 2B).

RETENTION

The patients were placed in retention with a Hawley retainer on 8 June, 1966, and were taken out of retention 6 months later on 6 December, 1966.

Table III.—REDUCTION OF OVERJET

DATE	CORAL	CHRISTINE
29 Aug., 1965	13·0 mm.	13·0 mm.
6 Oct., 1965	9·5 mm.	9·5 mm.
27 Oct., 1965	9·0 mm.	9·0 mm.
16 Nov., 1965	9·0/8·1 mm. (Change to No. 4)	7·3 mm.
7 Dec., 1965	8·0/6·5 mm.	6·4 mm.
16 Dec., 1965	6·0 mm.	5·0 mm.
8 Feb., 1966	5·0 mm.	4·5 mm.
1 Mar., 1966	1·7 mm.	4·5 mm.
23 Mar., 1966	Placed in retention	(Change to No. 4)
19 Apr., 1966	Placed in retention	1·5 mm. Placed in retention

An examination of the twins on 18 April, 1967, 5 months out of retention indicated little or no relapse. A cephalometric appraisal demonstrated no relapse in the case of Coral (*Fig.* 8C), but a slight upper incisor proclination in the case of Christine of the order of 3° (*Fig.* 5C). This had not produced any appreciable change in maxillary overjet, and therefore may be attributed to experimental error.

An examination of the twins on 31 January, 1968, 14 months out of retention, demonstrated no relapse, the occlusion had settled in satisfactorily and the position appeared stable.

COMMENTS

An interesting feature of the two twins is although they presented with dissimilar facial patterns in respect of apical base relationship and oromuscular activity, the arch form and relationship were similar in the two twins apart from the reflection of the body type. The response to treatment, as shown in *Fig.* 9, illustrates striking similarity. The delay in changing over to No. 4 elastics in the case of Christine is reflected in the falling off of the reduction of overjet, but was quickly made up on changing to a smaller elastic and therefore greater intermaxillary force.

Acknowledgements

I would like to thank Mr. P. H. Burke, Consultant Orthodontist, Addenbrooke's Hospital, Cambridge, for permission to report his patients and the help and advice in the preparation of this paper. In addition I wish to thank Mr. T. Crossley, Orthodontic Technician, and the Department of Medical Photography, Addenbrooke's Hospital for the preparation of the material.

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— — (1957), *Ibid.*, 60.
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DISCUSSION

Mr. F. Allan asked, in view of the fact that Professor Ballard had said that no retention was necessary in Class II, division 1 cases, why had retention been necessary in this particular case?

What criteria did the speaker use in coming to a decision as to whether extractions were necessary or not.

Mr. Hewitt replied that the reason he had not extracted in this case was because there was good basal bone, and it was thought that good results could be obtained without extraction. It was mentioned in the paper that if he had thought that the lower incisors were proclining excessively, then the maxillary second molars would have been the teeth of choice to extract.

Mr. P. H. Burke said that Mr. Hewitt should get the credit for the treatment and the case report, but that he himself should get the brickbats for the treatment planning in this case.

Mr. Burke said that anybody who had worked with him knew that he was a radical orthodontist, but he believed that there were patients who could be treated without extractions. In regard to these two patients, the testing time would come in 5 years time. He thought one case would stand up to wear, and the other, where the lower incisors had been proclined to 110°, would not.

Relevant to this, there was a paper published in the *American Journal of Orthodontics* in 1965 by Goldstein. He was involved in some work with Brodie and Downs, and they published the first cephalometric appraisal of orthodontic results in 1938. It was as a result of this work, in which it was established that one did not move mandibles, but just tilted teeth and altered the shape of the alveolar bone, that extractions were widely carried out in America. Goldstein compared some of his results, comparing extraction cases with non-extraction cases, during a follow-up period of 15 to 21 years, and he was not convinced that all patients were treated in the best possible way by carrying out extractions.

Mr. A. C. Campbell said that it appeared to him that in one case, the upper second molars at the end of treatment were markedly buccally placed, and this would suggest that there was not sufficient space to accommodate the full number of teeth. If the third molars had been present, then for that reason extraction might have been considered.

Mr. Hewitt replied that the third molars were present.

INVESTIGATIONS INTO CHANGES IN SOME MANDIBULAR ARCHES IN THE POSTDECIDUOUS DENTITION

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HAROLD CHAPMAN, whom we are honouring today, is generally regarded as this country's first orthodontic specialist and he was also a founder member of this Society. His professional life spanned the first half of this century, a period in the development of orthodontic theory and technique on which most of our present concepts of treatment are based.

As a member of Angle's course in 1906 he developed his technical skill, but it is also evident that technique never dominated his approach and his remarks in the Presidential Address at the European Orthodontic Society in 1938 would seem just as appropriate today: 'The progress of orthodontics depends on: A knowledge of the changes in dentures from birth to adult, and this is a study not of hours or days, but of a lifetime: diagnosis follows. Then comes clinical experience as the guide to treatment.'

We hope, that this paper would have been appreciated by Harold Chapman as a small contribution to this knowledge.

A common orthodontic problem is whether, or not, to treat the mandibular arch. Particularly is this so in Angle's Class II malocclusions where there are indications of slight mandibular crowding present at the time treatment in the maxillary arch is to be commenced. Although the work of Moorrees (1959) suggests there is little mean change in arch dimensions in untreated occlusions after the changeover from deciduous to permanent teeth has been completed, clinical experience of treated cases would seem to contradict this.

Cryer (1965) investigated the incidence and changes in lower incisor crowding in English children in their early teens and concluded that account should be taken of late lower incisor imbrication when orthodontic treatment is planned.

It was in an attempt to shed more light on this problem of late lower incisor imbrication that the present investigations were carried out.

It is a commonly held clinical impression that movement of teeth in the buccal segments of one arch has some influence on the position of those in the opposing arch and this is thought to be related to cuspal incline and interdigitation factors. (Certainly the stability of treated malocclusions would seem to be influenced by cuspal relationships.) Also, it would seem that orthodontic treatment, involving extractions, of the upper arch only, has the effect of increasing late lower labial segment imbrication beyond the degree that would have been expected to occur had there been no orthodontic interference to the occlusion.

Björk (1951) has shown that the late lower labial segment imbrication may be associated with a mean slight uprighting of the lower incisors, occurring presumably as the result of a change in their soft-tissue environment, and possibly a slight relative increase in mandibular prognathism. Jones (1966) found that out of 26 cases nearly two-thirds showed lingual tilting of the lower incisors relative to the mandibular plane between 10 and 15 years of age. Also, it is difficult to evaluate the part played by the developing lower third molars in encouraging mesial drift of the buccal segments at the expense of lower labial segment alinement. These teeth have been blamed for the occurrence of much of the late crowding in the past, but as this has also been observed to occur where third permanent molars were absent, their importance is uncertain (Bergström and Jensen, 1961; Vego, 1962). It is only by longitudinal growth studies of untreated occlusions with adequate records

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Chapman Prize Essay presented at the meeting held on 12 February, 1968.

followed by careful statistical evaluation that a better understanding will be gained.

SURVEY OF THE LITERATURE

One of the earliest references to arch length must have been by John Hunter (1771) who stated that, after the twelfth month, the jaw does not increase in length between the symphysis and sixth tooth, but rather lengthens at its posterior ends.

Most subsequent investigations have concentrated on changes in arch dimensions during the changeover from deciduous to permanent dentitions. References to lower incisor crowding in treated cases seem to be concerned mainly with the results of using intermaxillary traction (Pringle, 1955; Kloehn, 1961).

Smyth and Young (1932) made direct intraoral measurements at 6-monthly intervals on approximately 50 children of each sex, aged 8 to 14 years. The mean arch length showed a tendency to decrease after 10 years of age, particularly in the mandible, but most of this must have been associated with the replacement of deciduous molars by the smaller premolars.

Nance (1947) also dealt with a younger age-group than the subject of this paper, but his methods are of interest. Mandibular arch length was measured between the mesial surfaces of first molars by taking straight segments of the arch with dividers and determining the sum of the segments. Two other measurements were made. The arch perimeter was measured, using a length of 0·010 in. brass wire touching the middle third of the teeth around the arch; and the ' inside measurement ' made by placing divider points at the mesiolingual of the first molars and the gingival margin between the centrals on the lingual aspect.

Speck (1950) measured arch length by an intricate photographic method along the line of the centres of contact areas.

He pointed out that arch length measured along the midline from a base between corresponding, bilateral dental points, and the interincisal point is misleading. This is because a decrease in length of this line, if accompanied by an increase in width, may be found in association with an actual increase in circumferential arch length.

Brown and Daugaard-Jensen (1950) investigated changes in the dentition of 40 individuals from early teens to the early twenties. Sixteen had received unspecified orthodontic treatment.

Lower intercanine width, measured between the tips, showed a decrease in 75 per cent of the untreated cases and rather more in the treated cases. Intermolar width, measured between the buccal grooves, also tended to decrease in both groups.

Arch length was taken from the anterior midpoint perpendicular to the transverse line connecting the two points used for measuring intermolar width. The length was computed by Pythagoras' Theorem. All except one case in each group showed a decrease. These workers also made a subjective assessment of incisor crowding as slight +, definite ++, or extreme +++.

Moorrees (1959) made a detailed study on the casts of 184 children up to the age of 18 years. The majority were classified as having normal occlusion, and he utilized only the data from these. No orthodontic treatment cases were included.

Arch length was measured as the distance between a line tangent to the labial surfaces of the central incisors and a line connecting the most dorsal points on the distal surface of the second deciduous molars or second premolars. He found that the arch length is smaller at 18 years than at 3 years, as would be expected, but he found that from 14 to 18 years the changes were minimal.

Arch breadth was measured between the tips of the crowns of the canines and the mesiolingual cusps of first molars. The buccal grooves of first molars were not used as these were often destroyed by caries. The greatest canine width was found to occur at the time of eruption, and this was followed by a slight decrease but little change after 12 years.

The mean molar width increased appreciably at 13 years in boys and 11 years in girls. Arch circumference was also measured using a piece of curved 0·15 mm. stainless-steel wire bent along the buccal cusps and incisor edges. This measurement tended to be smaller at 18 years than at 5 years, but could increase slightly or decrease greatly. Crowding was assessed by subtracting the space available in the arch from the mesiodistal diameter of each tooth.

Knott (1962) measured the casts of 13 girls and 16 boys for arch width and depth (i.e., arch length) from ages 9 to 17 years. They were all untreated, good occlusions. She found that arch width increased over the age period studied, although there was a tendency for a levelling off in girls over 13 years. Arch length decreased in both sexes throughout the period.

Sillman (1964), in a valuable contribution, measured 750 casts of 65 individuals, 40 having been recorded longitudinally from birth to 25 years. They included all types of occlusion, including treated cases.

The work was shared by two investigators and the error of measurement was determined by computing the mean differences between measurements on casts of one individual from birth to 23 years (twenty double determinations). The relevant points used for measurements in this case were the crest of the interdental septum

between the centrals, the mesial aspect of the first molars, and the distal of the canines.

The mandibular arch length showed a significant decrease from 10 to 17 years, but no significant later change. The canine width remained the same after 12 years and the molar width showed a slight but significant increase (0·2 mm. per year) up to the age of 14 years and then no change.

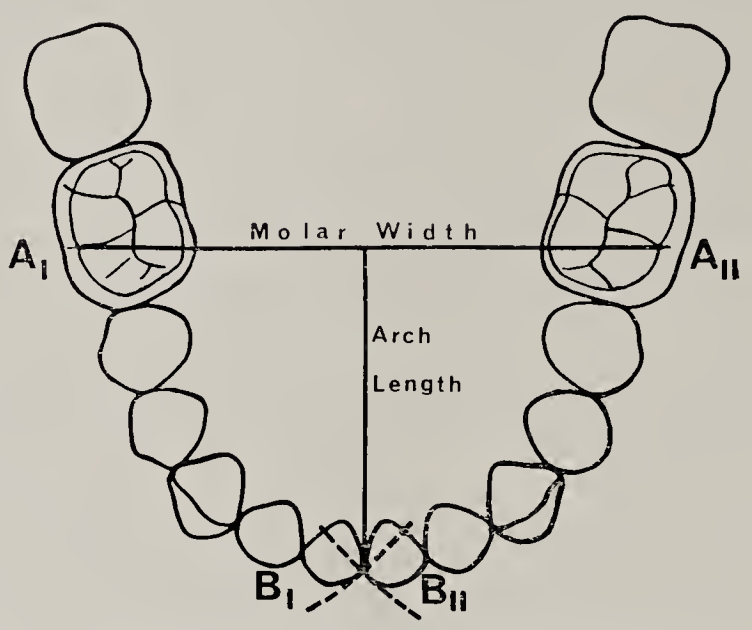

Fig. 1.—Diagram of the lower arch to show the method of measuring arch length.

FIRST INVESTIGATION

Having no adequate control group available, it was thought that some information might be gained by an investigation comparing the effects on untreated mandibular arches of treating the maxillary arch, by (1) distal movement of upper buccal segments (D.M.U.B.S.) with or without the extraction of the upper second permanent molars (this was designated Group A) and by (2) extraction of an upper premolar bilaterally (PM|PM), when it can be assumed that the upper buccal segments are likely to move mesially during treatment and, indeed, in many cases are required to do so, if the space created by the extractions is more than is necessary to reduce an overjet and/or aline the upper labial segment (this was designated Group B). Obviously, if the anchorage was reinforced (e.g., by extra-oral anchorage), a case could not be considered for this group. Although none of the cases in either group A or B had received any orthodontic treatment in the mandibular arch, it may, however, have been ' influenced ' in one or more of the following ways:—

1. By the use of a horizontal anterior bite plane on upper removable appliances.

2. By a change in soft-tissue environment.

a. Temporarily as a result of the volume of an upper removable appliance being present in the mouth.

b. Permanently by a change in the mode of anterior oral seal during swallowing and at rest—the lower lip functioning in front of the upper labial segment rather than behind it.

3. By a mandibular displacing activity ceasing or commencing.

4. By transmission of orthodontic forces through the upper incisors to the lower incisors.

It was hoped that if these factors did influence the changes in the lower arches, their overall effect would tend to balance out in the two groups.

The first measurements of the lower arches were not taken until the lower second premolars and canines had fully erupted, i.e., the change-over from the deciduous to the permanent dentition with any concomitant driftings was complete in the lower arch. They were then repeated as long as possible after orthodontic treatment was completed (the range between measurements in this study being 14–102 months).

Material

Each group consisted of 26 cases and each of the 26 cases in Group A was closely matched against a case in Group B for time interval between the first and second measurements. The mean time difference between the first and second readings in the Group A cases exceeded that in the Group B cases by less than 0·2 month. The time of the first measurement corresponded to the commencement of treatment in a few cases only. Many were from models taken a short time before treatment was commenced and others at varying periods afterwards (the delay was the result of waiting for the full eruption of the lower second premolars and canines). The mean time interval between the commencement of treatment and the first measurement was 5·5 months for Group A and 5·0 months for Group B. The Angle's classification of the malocclusions differed in the two groups as follows: Group A consisted of 10 Class II, division 1, 3 Class II, division 2, and 13 Class I malocclusions. Group B consisted of 16 Class II, division 1, 6 Class II, division 2, and 4 Class I malocclusions.

Method

It was decided to record changes in the mandibular arch by means of three measurements: an arch length, a molar width, and a canine width. Dividers were used, and the readings transferred directly to 1 mm.-square graph paper.

The arch length chosen is shown in *Fig.* 1. Points A_1 and A_{11} lie at the junction of the buccal grooves with the occlusal surfaces of the lower first permanent molars. Points B_1 and B_{11} are the most outstanding (labially placed) points on the mesial surfaces of lower right and left central incisor crowns, established by the dividers. (The position of B point on the lower central incisor crown varies with the angulation of the tooth.)

The two models of each case were examined closely and the junction of the buccal groove and occlusal surface carefully marked with a soft, but sharp, pencil. By comparing the two models an attempt could be made to allow for changes due to attrition or restorations (i.e., other anatomical points such as the mesiolingual cusp tip were used, if necessary to establish the same A points on both models as accurately as possible). However, any gross changes in the anatomy of the first molar served to reject the case. One point of the dividers was placed on A_1 and the other adjusted to rest on point A_{11}. This distance was then transferred to the graph paper and used as the molar width recording. One point of the dividers was then placed on point A_1 and the other adjusted to just touch the most outstanding point on the mesial surface of the lower right central incisor (B_1). This distance was then transferred to the graph paper by placing one point into the A_1 recording and scratching an arc with the other. The procedure was repeated for A_{11} and B_{11} and this similarly transferred. Where the two arcs crossed was used as the anterior limit of the arch length, the arch length recording being read off in millimetres from the graph paper as the distance between the anterior limit and the line on to which A_1 and A_{11} had been transferred. Finally, a measurement of canine width was taken by

Table I.—Comparison of the First Readings and a Comparison of the Second Readings of Groups A and B

	First Readings				Second Readings				
	Difference between Means (mm.)	*Standard Error of the Difference* (mm.)	*t*	*P*	*Difference between Means* (mm.)	*Standard Error of the Difference* (mm.)	*t*	*P*	*n*
Arch length	−0·13	0·45	0·29	>0·7	−0·18	0·53	0·15	>0·8	26
Molar width	0·12	0·74	0·16	>0·8	0·10	0·85	0·12	>0·9	26
Canine width	0·26	0·54	0·48	>0·6	0·71	0·58	1·20	>0·2	26

— Indicates that the reading for Group B is larger than for Group A.

Table II.—Showing the Changes in Arch Dimensions following D.M.U.B.S. in the Upper Arch (Group A) and Anteroposterior Contraction (Group B)

	Group A				Group B				
	Mean Difference First and Second Reading (mm.)	*Standard Error of the Difference* (mm.)	*t*	*P*	*Mean Difference First and Second Reading* (mm.)	*Standard Error of the Difference* (mm.)	*t*	*P*	*n*
Arch length	−1·03	0·16	6·42★	<0·001	−1·08	0·14	7·47★	<0·001	26
Molar width	0·03	0·24	0·11	>0·9	0·05	0·15	0·03	>0·9	26
Canine width	−0·17	0·15	1·11	>0·2	−0·62	0·22	2·81†	<0·01	26

★ Significant at the 0·1 per cent level
† Significant at the 1·0 per cent level

placing the points of the dividers on to the tips of the canine crowns (or the centre of the occlusal areas if the tips showed attrition) and transferring this to the graph paper. The measurements from both models of the same case were always made at the same sitting. This investigation was a joint one, but it was found necessary to share the task of making the recordings between the two investigators rather than having both investigators record every measurement. However, in an attempt to standardize the measuring procedure, 25 cases (i.e., 63 separate measurements of each dimension) were first measured by both investigators. These double determinations were tested statistically using the method described by Dahlberg (1948). The standard error of a single determination of change of lower arch length was 0·13 mm., of molar width change was 0·20 mm., and canine width change was 0·20 mm., and hence it would appear that the errors of the method were within acceptable limits. Each of the remaining cases was measured by only one investigator, both investigators measuring approximately equal numbers. In choosing the cases an attempt was made to match the groups for the numbers of cases measured by both investigators (D.A. and M.L.B.), and also for the numbers of each sex chosen, as well as for the time interval as described above. (Group A: D.A., 13 cases; M.L.B., 13 cases; Female 15, Male 11. Group B: D.A., 13 cases; M.L.B., 13 cases; Female 16, Male 10.)

Results

A comparison was made between the mean values of the initial readings of arch length, molar width, and canine width for Groups A and B using the '*t*' test (*Table I*). This showed that their differences were within the range that could be attributed to chance ($P>0{\cdot}7$, 0·8, and 0·6 respectively) and thus the groups were comparable. This procedure was repeated for the second readings with similar results ($P>0{\cdot}8$, 0·9, and 0·2 respectively) (*Table I*).

The mean changes between the first and second measurements of the three dimensions were recorded for both Group A and B and are shown in *Table II*. It can be seen that the arch length reduced by a similar amount on average in both groups, the molar width increased very slightly in both, and the canine width reduced in both, but to a greater extent in Group B cases on average.

A comparison using the paired '*t*' test between the first and second measurements of each dimension in each group was then made (*Table II*). It can be seen that the average differences between the first and second measurements of arch length in both Groups A and B are greater than can be attributed to chance (significant at the 0·1 per cent level). The average difference between the first and second measurements of molar width of both Groups A and B are within the range that can be attributed to chance. Finally, although the average differences between the first and second measurements of canine width in Group A were within the range that can be attributed to chance, a similar comparison in Group B showed that the differences were greater than can be attributed to chance (1 per cent level of significance).

Discussion

Clearly the cases making up the two groups were similar initially for average arch length, molar width, and canine width dimensions. After treatment involving the upper arch only, there was a similar marked average decrease in lower arch length in both groups, the average molar width remained virtually unchanged and the average canine width showed a decrease in both groups. The decrease in Group A being on average very small and not significant whereas in Group B it was more marked and significant at the 1 per cent level. Hence late lower labial segment imbrication could be expected to occur in both groups and if, in fact, it tends to be greater in those cases where there has been anteroposterior contraction in the upper arch (i.e., Group B) as clinically one suspects, then the mechanism would appear to be a greater tendency to a reduction in the lower canine width. The addition of a measurement of mandibular arch perimeter to our readings might well have been of value in assessing any difference in late lower incisor imbrication between the two groups. The mesial drift in the lower buccal segments, and/or retroclination of lower incisors, is equally marked irrespective of the direction of the tooth movements in the upper arch. The extraction of PM|PM seems to be associated with an increased tendency to reduction in the lower canine width.

Table III.—Mean Initial Readings for Arch Dimensions for Groups A, B, and C

	Arch Length (mm.)	Molar Width (mm.)	Canine Width (mm.)	*n*
Group A	26·46	46·01	26·05	8
Group B	26·90	44·48	24·86	8
Group C	26·86	46·38	26·60	8

SECOND INVESTIGATION

It was thought that further information might be gained by introducing comparison with another group, designated Group C. This consisted of cases who had received no

treatment in the lower arch apart from the extraction of the lower second permanent molars, whilst the upper arch had been treated in either of the ways considered in the first investigation (i.e., D.M.U.B.S. or extraction of PM|PM). As the extraction of the lower second permanent molars is not commonly carried out at the Eastman Dental Hospital, we were able to find only 8 cases for this group. Eight cases were chosen from both Groups A and Group B to match those of Group C for time interval, sex, and number measured by each investigator.

Method

The same method of measurement was used for the second investigation as had been for the first, and the same procedure was employed.

Table IV.—Comparison of the First Readings and a Comparison of the Second Readings of Arch Length for Groups A, B, and C

	First Readings				Second Readings				
	Difference between Means (mm.)	*Standard Error of the Difference* (mm.)	*t*	*P*	*Difference between Means* (mm.)	*Standard Error of the Difference* (mm.)	*t*	*P*	*n*
Groups A and B	−0·44	0·86	0·51	>0·6	−0·18	0·97	0·18	>0·8	8
Groups A and C	−0·40	0·74	0·54	>0·6	−1·85	0·70	2·67*	<0·05	8
Groups B and C	0·04	0·90	0·048	>0·9	−1·68	0·93	1·80	>0·1	8

* Significant at the 5 per cent level

Table V.—Showing the Changes in Lower Arch Dimensions in Groups A, B, and C following Treatment of the Upper Arch

	Group A				Group B				Group C				
	Mean Difference First and Second Reading (mm.)	*Standard Error of the Difference* (mm.)	*t*	*P*	*Mean Difference First and Second Reading* (mm.)	*Standard Error of the Difference* (mm.)	*t*	*P*	*Mean Difference First and Second Reading* (mm.)	*Standard Error of the Difference* (mm.)	*t*	*P*	*n*
Arch length	−0·74	0·18	4·16*	<0·01	−1·0	0·21	4·84*	<0·01	0·73	0·24	3·01†	<0·02	8
Molar width	−0·09	0·43	0·20	>0·8	−0·01	0·34	0·03	>0·7	1·08	0·42	2·57‡	<0·05	8
Canine width	0·06	0·29	0·21	>0·8	−0·58	0·39	1·48	>0·1	−0·73	0·24	3·08†	<0·02	8

* Significant at the 1 per cent level
† Significant at the 2 per cent level
‡ Significant at the 5 per cent level

Results

When the mean values of the initial readings of arch length, molar width, and canine width were calculated for these small groups, it was found that only in arch length dimension were the groups comparable (*Table III*). A comparison was then made between the initial readings for arch length for Groups A and B, A and C, and

B and C using the ' *t* ' test, when it was found that the differences were all within the range that could occur by chance (*Table IV*). This was repeated for the second readings of arch length, when it was found that the differences between for Groups A, B, and C are shown in *Table V*. It can be seen that in Group C the arch length increased rather than reduced, the molar width increased relatively markedly, and the canine width reduced to a greater extent.

Table VI.—Group C—Mean Changes between First and Second Readings

	Mean Changes between First and Second Readings			
	Arch Length (mm.)	*Molar Width* (mm.)	*Canine Width* (mm.)	*n*
Group C All cases	+0·725	+1·075	−0·725	8
Group C Those cases in which the upper arch was treated by D.M.U.B.S.	+1·025	+1·425	−0·425	4
Group C Those cases in which the upper arch was treated by A.P.C.	+0·425	+0·825	−1·015	4

− Indicates a reduction in the dimension
+ Indicates an increase in the dimension

Table VII.—Group C—Difference between First and Second Readings

	Time Interval (Months)	Arch Length (mm.)	Molar Width (mm.)	Canine Width (mm.)
Group C Those cases in which the upper arch was treated by D.M.U.B.S.	30	+0·4	+3·0	+0·6
	34	+1·0	+1·1	−0·8
	48	+0·5	+0·3	−0·9
	53	+2·2	+0·9	−0·6
Group C Those cases in which the upper arch was treated by A.P.C.	30	+0·2	+2·0	−0·5
	44	+0·6	+1·9	−1·4
	44	0·0	0·0	−0·6
	53	+0·9	+0·6	−1·6

− Indicates a reduction in the dimension
+ Indicates an increase in the dimension

Groups A and B, and Groups B and C were also within the range that could be attributed to chance, whereas between Groups A and C the difference was greater than could be expected by chance and significant at the 5 per cent level (*Table IV*).

The mean changes between the first and second measurements of the three dimensions recorded

A comparison using the paired ' *t* ' test between the first and second measurement of each dimension in each group was then made (*Table V*). It can be seen that the changes in arch length in all three groups were greater than can be expected by chance. (Significant at the 1 per cent level for Groups A and B and at the 2 per cent level for Group C.) The changes in molar width were

within the range that can be attributed to chance in both Groups A and B. However, in Group C the change in molar width was greater than can be expected from chance (significant at the 5 per cent level). Similarly, the changes in canine width were within the range that might be expected by chance in both Groups A and B. But in Group C the changes were greater than could be expected from chance (significant at the 2 per cent level).

Discussion

Irrespective of the clinical value of the extraction of the lower second permanent molars in orthodontics, the use of the procedure in this second investigation can be seen to have revealed some interesting information. The very small sample size must, however, be remembered.

It would seem that the relief of any potential crowding factor at the distal end of the lower arch by the extraction of the lower second permanent molars results in at least a temporary check in the mesial drift of the lower buccal segments, possibly even allowing an actual slight distal drift of the lower first permanent molars to occur. Note that there is an average increase in arch length, and an average increase in molar width (*Table V*)—suggesting a movement of the lower first permanent molars to a more distal and, therefore, a wider part of the arch. Cryer (1965) noted some reduction in lower arch crowding following extraction of lower second permanent molars.

It is interesting to break down Group C into two sub-groups (of 4 cases each) according to the treatment carried out, in the upper arch (i.e., D.M.U.B.S. or extraction of $\underline{\text{PM|PM}}$) for arch length and molar width (*Table VI*). These results would seem to suggest, in conjunction with those of the first investigation, that where the lower second permanent molars are extracted the teeth in the lower arch are more liable to be influenced by the direction of the tooth movements in the upper arch. Also, if the recordings are placed in order of increasing time interval (*Table VII*), they suggest that the increase in molar width may be of a more transitory nature than the increase in arch length. Breaking down Group C into two sub-groups as above with regard to canine width changes (*Table VI*) would seem to confirm the effect on the lower arch of the extraction of $\underline{\text{PM|PM}}$ that was found in the first investigation—the extraction of the lower second permanent molars tending to exaggerate it. From *Table VII* it would seem that this effect is possibly a stable one. (Measurements of maxillary arches, with regard to dimension changes following treatment involving D.M.U.B.S. or $\underline{\text{PM|PM}}$ extractions, would be of interest, as one would expect the upper canine width to increase as the teeth are retracted to a wider part of the arch, irrespective of whether $\underline{\text{PM|PM}}$ had been extracted or not.) This does seem to suggest the importance of an intact arch with tight contacts in maintaining maximum arch dimensions.

It is also not surprising that orthodontists have been disappointed by late canine width ' collapse ' in treated cases involving extractions (e.g., ' Lower canine width is now less than the original width, which isn't fair!', Halden, 1959), when these results show that, on average, there occurs a reduction of over $\frac{1}{2}$ mm. in lower canine width in an intact lower arch when $\underline{\text{PM|PM}}$ have been extracted. It would seem likely that the extraction of $\overline{\text{PM|PM}}$ will tend to exaggerate this tendency even with careful handling using fixed appliances.

Finally, by inference, it would seem that the lower third permanent molars are likely to have an influence on late arch changes.

SUMMARY

An investigation was made comparing the changes in untreated mandibular arches when the maxillary arches were treated orthodontically in one of two ways: Group A where the maxillary arches were treated by D.M.U.B.S. (26 cases) and Group B where it was treated by extraction of $\underline{\text{PM|PM}}$ (26 cases) It was found that:—

1. The mandibular arch length decreased by a similar amount on average in both groups (mean of approximately 1·0 mm.).
2. The molar width increased very slightly on average in both groups (mean of approximately 0·05 mm.).
3. The canine width reduced on average in both groups, but to a greater extent in Group B cases (0·17 mm. compared to 0·62 mm.).

A second investigation introduced a further group (Group C), in which the mandibular arches had received no treatment other than the extraction of $\overline{7|7}$ when the maxillary arches were treated by D.M.U.B.S. or extraction of $\underline{\text{PM|PM}}$. Group C consisted of only 8 cases and these were matched with 8 cases from Group A and 8 cases from Group B. It was found that the Group C cases showed:—

1. An increase in lower arch length on average of approximately 0·7 mm.
2. An increase in molar width on average of approximately 1·0 mm.
3. A reduction in canine width on average of approximately 0·7 mm.

CONCLUSIONS

1. Consideration must be given to the problem of late lower incisor imbrication in treatment planning irrespective of the type of orthodontic treatment prescribed for the maxillary arch.
2. If late lower incisor imbrication is more marked when maxillary premolars are extracted

as part of the orthodontic treatment, then the mechanism is likely to be related to a greater reduction in lower canine width.

3. The extraction of $\overline{7|7}$ reduces the tendency to late imbrication of the lower labial segment (but the prognosis for satisfactory eruption of $\overline{8|8}$ is uncertain).

4. It is suggested that the extraction of $\overline{7|7}$ removes a ' crowding ' factor (at least temporarily) from the back of the mandibular arch. This:

a. May halt the tendency to mesial drift.

b. May allow actual distal drift to occur with an improvement in imbrication in the mandibular arch.

c. May result in the direction of maxillary tooth movements having some influence on mandibular tooth movements.

d. May allow the extraction of $\underline{PM|PM}$ to have a greater effect on mandibular canine width reduction.

5. By inference, (*a*) it would seem that tight contacts are important in maintaining maximum arch dimensions and (*b*) mandibular third molars are likely to be an influence in late mandibular arch changes.

Acknowledgements

We would like to thank Professor C. F. Ballard, Mr. S. G. McCallin, Dr. J. R. E. Mills, and Professor D. P. Walther for permission to use the records of their patients; Dr. Mills for his criticism; Mr. A. Richardson for his comments and encouragement, and Dr. Merrett for his advice particularly with regard to the statistical appraisal. Thanks are also due to Miss J. Jeffrey and Miss Henry for their secretarial assistance.

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DISCUSSION

Mr. J. R. Halden asked what precautions were taken to distinguish between mesial movement of the buccal segments and posterior movement of the labial segments. If there was no treatment in the lower arch, presumably the overbite was not reduced. Therefore, reduction of the upper incisors could have brought reduction of the lower incisors too. He would have expected the canines to expand rather than the width to decrease, as apparently was the case. Could the speakers comment on whether they distinguished between the two?

Mr. M. L. Brenchley replied that no distinction had been made. Undoubtedly there was an effect on the lower incisors, but it was hoped that the two groups would balance out; there was no way of separating them.

Mr. K. E. Pringle said that the authors had mentioned three different groups, Class II, division 1, Class II, division 2, and others. Were the authors quite satisfied that they were comparing like with like, and was any attempt made to compare like with like?

Mr. Brenchley replied that the only similarity in the two groups, A and B, was the fact that the consultants who had diagnosed the cases thought that the lower arches were all acceptable and need not be treated. This meant that Groups A and B had different numbers of Class II, division 1 and so on, so they were not identical from an occlusal point of view. They had to measure the material as they collected it and consequently they ended up by measuring over 100 cases. When they had tried to match them for time difference between measurements, sex, and the two investigators measuring the cases, they had come down to 26. If they had included Angle's classification, they might have been down to 8 cases, as in the second investigation, which would not have been statistically valid.

The President then presented the Chapman Prize to Messrs. Ardouin and Brenchley.

REINFORCED OCCIPITOMENTAL TRACTION AND ITS EFFECT ON THE INCISOR TEETH IN CLASS III MALOCCLUSIONS

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During the past 13 years valuable contributions on various aspects of Class III malocclusion have been made by McCallin (1955), Hopkin (1962), and Mills (1966). However, treatment of this condition by means of extra-oral traction has received little attention and the value of chin-cap therapy appears to be uncertain.

The chin-cap is not new; Kneisel (1836) and Gunnell (1842) were the first authorities to advocate the orthodontic potential of a leather chin-cap to produce an upwards and backwards thrust on the chin. Subsequently, Westcott (1844), Sewill (1869), Allen (1879), and Wardle (1879) all described its beneficial effects but, by 1907, Angle concluded that occipitomental traction had been superseded by the introduction of fixed appliance therapy and Class III intermaxillary traction.

More recently, Gold (1949), Chapman (1950, 1952) and Gold and Gilbert (1959) re-stimulated interest in this form of appliance, but their reports omitted cephalometric measurements. Armstrong (1961, 1963) and Thilander (1963) investigated larger groups of patients and used cephalometric analysis. Armstrong used a simple plastic chin-cap to treat 62 patients with Class III malocclusions, but found it was effective in only 40 per cent of the cases and concluded that extra-oral traction had a limited application. Thilander used webbing head and chin-caps to treat 60 children aged 5 to 16 years and concluded that the chin-cap was a valuable aid in the treatment of cases of prenormal occlusion, especially in patients under 12 years of age. However, even these latest reports appear to present divergent results and so far only simple extra-oral traction has been employed.

Kettle and Burnapp (1955) pioneered the concept of reinforced occipitomental traction by harnessing elastic tension between a maxillary appliance and an acrylic chin-cap. However, this work was undertaken on cleft palate patients affected with reversed overjets.

As the literature review failed to reveal any comparable investigation examining the effectiveness of using reinforced occipitomental traction for treating Class III malocclusions, the present study was undertaken.

Table I.—A Comparison of the Accuracy of Measurements Obtained from Lateral Skull Radiographs and Orientated Study Models

Measuring Method	Angulation Recorded	Method Precision (Standard Deviation)	Number of Results
Lateral skull radiographs	$\frac{1}{1}$ Maxillary Plane	2·22°	90
	$\frac{\overline{1}}{\overline{1}}$ Mandibular Plane	2·29°	90
Orientated study models	$\frac{1}{1}$ Frankfurt Plane	1·03°	120
	$\frac{\overline{1}}{\overline{1}}$ Mandibular Plane	1·10°	120

AIM AND METHOD OF INVESTIGATION

The primary aim of the present investigation was to assess as accurately as possible the short-term changes occurring in the angulation of the maxillary and mandibular incisors when a group of Class III malocclusions was treated with reinforced occipitomental traction.

Presented at the meeting held on 11 March, 1968.

Cephalometric analysis is the time-honoured method for assessing such changes and this analysis was undertaken on all patients in this investigation. However, a number of recent publications including those by Broadway, Healy, and Poyton (1962), Backlund (1963), Mills (1964), and Bennett (1966) have indicated that certain measurements, especially those involving the angulation of the incisor teeth, can be liable to variation and error. Furthermore, the hazard of excessive radiation means that lateral skull radiography cannot be repeated at really frequent intervals, especially in young children.

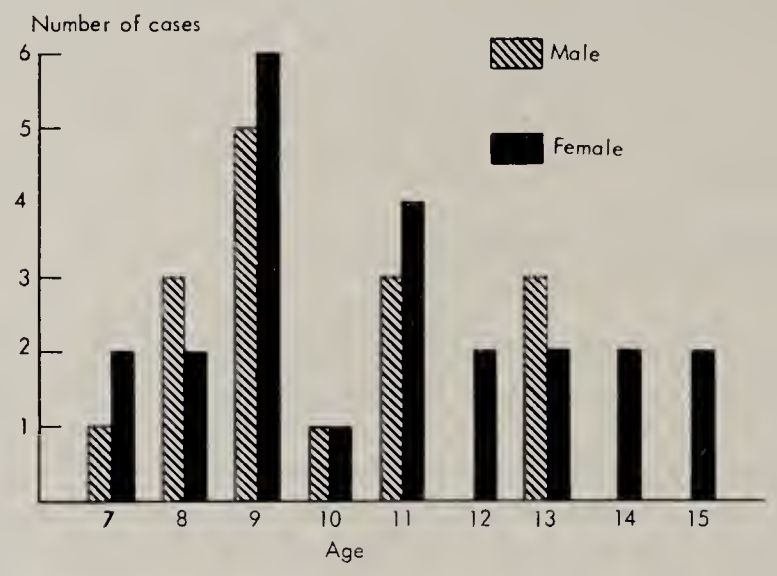


Fig. 1.—Experimental Group A—39 cases.

The problem of being able to measure the angulation of the incisor teeth at approximately 3-weekly intervals throughout a course of orthodontic treatment was overcome by using the orientated study model technique and special vernier measuring apparatus described elsewhere, (Bennett and Smales, 1968). Previous studies (Bennett and Smales, 1965; and Bennett, 1966) have proved that this method was simple, easily and frequently repeatable, and that measurements of incisal angulation were significantly more accurate than comparable measurements obtained from lateral skull radiographs (*Table I*). Therefore, it was decided to use this technique on a number of patients in the present investigation.

CLINICAL MATERIAL

Fifty children with Class III malocclusions formed the clinical material. There were 22 boys with a mean age of 9 years 3 months (range 6–12 years) and 28 girls with a mean age of 9 years 6 months (range 6–14 years). In all children the permanent upper central incisors were erupted before appliance therapy was begun.

The patients were divided at random into two groups:—

Experimental Group A (*Fig.* 1)

This consisted of 39 patients and in this group all measurements were obtained solely from cephalometric analysis.

Lateral skull radiographs were recorded; at the first examination, the commencement and cessation of tooth movement, and, thereafter at about 6–12-monthly intervals.

Experimental Group B (*Fig.* 2)

This consisted of 11 patients and in these children measurements were obtained by both cephalometric and orientated study model methods.

Fig. 2.—Experimental Group B—11 cases.

Lateral skull radiographs were recorded at the same stages as in Group A subjects.

Orientated study models were obtained at 3-weekly intervals, first, for a period of about 12 weeks before appliance therapy started, and this provided a base line for all future measurements. Similar models were obtained at 3-weekly intervals throughout the period of appliance therapy and, also, for at least 3 months after appliance therapy had ceased.

THE ORTHODONTIC APPLIANCE

A standardized appliance was used on each patient and this consisted of four parts:—

1. *The Head-cap* (*Fig.* 3 A)

This was constructed from $\frac{1}{2}$-in. wide transparent ' Portex ' P.V.C. strapping. Joints were made by melting opposing surfaces of the material with a hot wax knife and cuts in the strapping allowed for the attachment of elastic bands.

2. *The Chin-cap* (*Fig.* 3 B)

A composition impression was obtained of the chin and an acrylic chin-cap constructed. Hooks for attachment of elastic bands were incorporated on each side of the chin-cap. At the fitting stage, two short lengths of $\frac{1}{8}$-in. diameter perspex rod were cold-cured to the chin-cap and these posts were positioned so as to project slightly above the red margin of the upper lip.

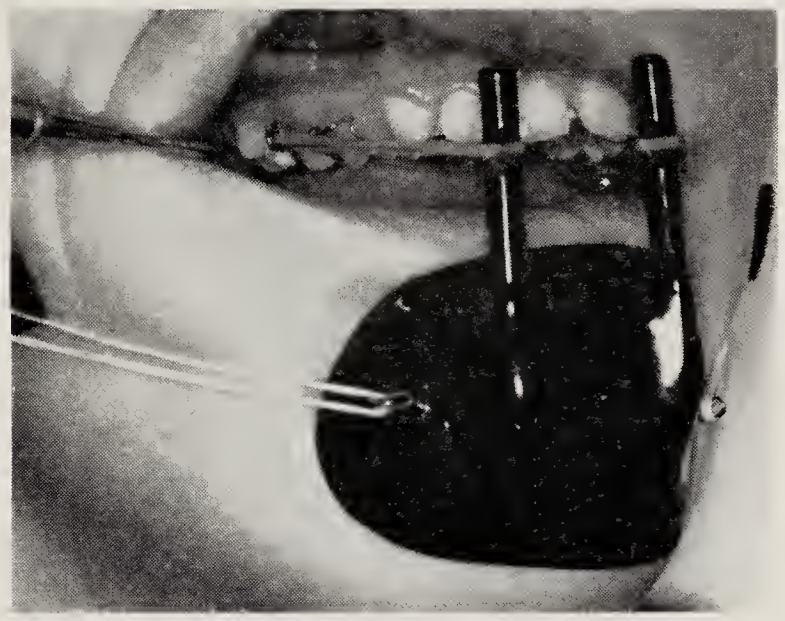
3. *The Intra-oral Appliance* (*Fig.* 3 C)

Only removable appliances were used in this investigation. They were retained by Adams's clasps on the most posterior teeth and, wherever possible, additional teeth were similarly clasped.

A

B

C



D

Fig. 3.—Apparatus for producing reinforced occipitomental traction. A, The headcap. B, The chin-cap. C, Typical maxillary appliances. D, The attachment of the intra-oral and extra-oral elastics.

Hooks for the attachment of elastic bands were soldered to the bridges of the most posterior clasps. No capping, springs, or screws were incorporated in the appliance, but the acrylic resin was made to contact the palatal aspects of all maxillary incisor teeth.

4. *The Elastic Bands* (*Fig.* 3 D)

Two elastics connect the head and chin-cap together whilst the two additional elastics pass from grooves on the Perspex rods to the hooks distally on the intra-oral appliance.

Mode of Action of Appliance

The mechanics of this type of appliance can be illustrated by *Fig.* 4. The intra-oral elastics produced a two-fold action. First, they pulled the chin-cap towards the lower lip so that the lip pressed the lower incisors lingually. Secondly, they caused the maxillary appliance to transmit a forwards thrust onto the palatal aspects of all the maxillary teeth.

The whole apparatus was worn only at nights. The size of the elastic bands was varied according to the distance between the points of attachment, but, in all instances, the aim was to effect a tension of about 8 oz. (230 g.) on each elastic. Clinically, this amount of tension could be obtained when the activated elastics were stretched to about double their original length. New elastics were used each night.

RESULTS

Forty-eight children completed the period of appliance therapy and the remaining 2 cases discharged themselves during treatment.

The results may be considered under a series of headings.

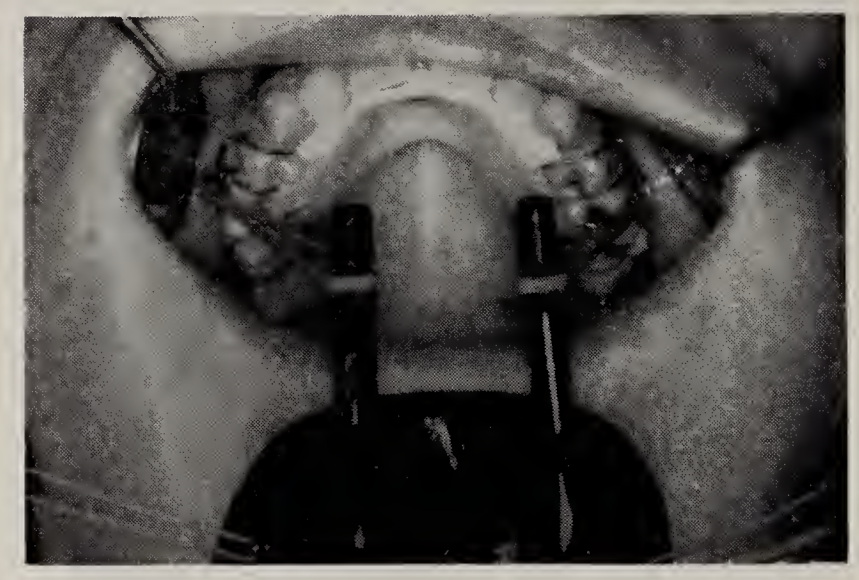


Fig. 4.—The intra-oral elastics produce a two-fold effect. The chin-cap is pulled against the lower lip and this retroclines the lower incisors. At the same time the upper appliance is pulled forwards and proclines the maxillary incisors.

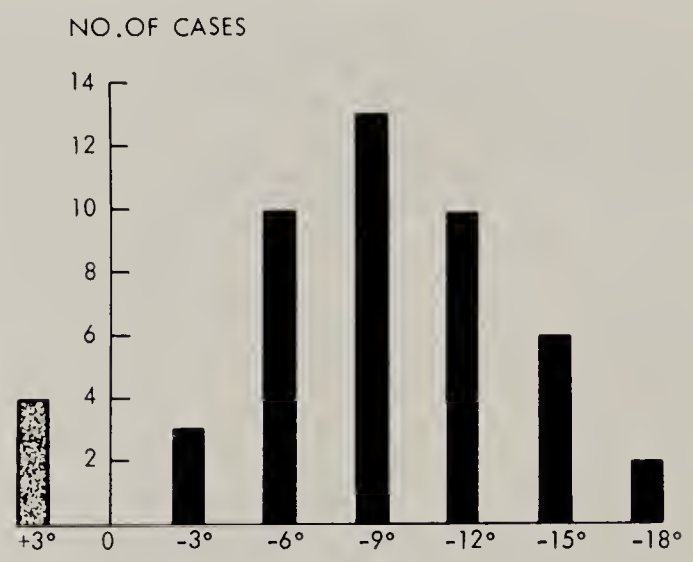


Fig. 5.—Changes recorded in the angulation of the mandibular central incisors following reinforced occipitomental traction. Measurements recorded from lateral skull radiographs.

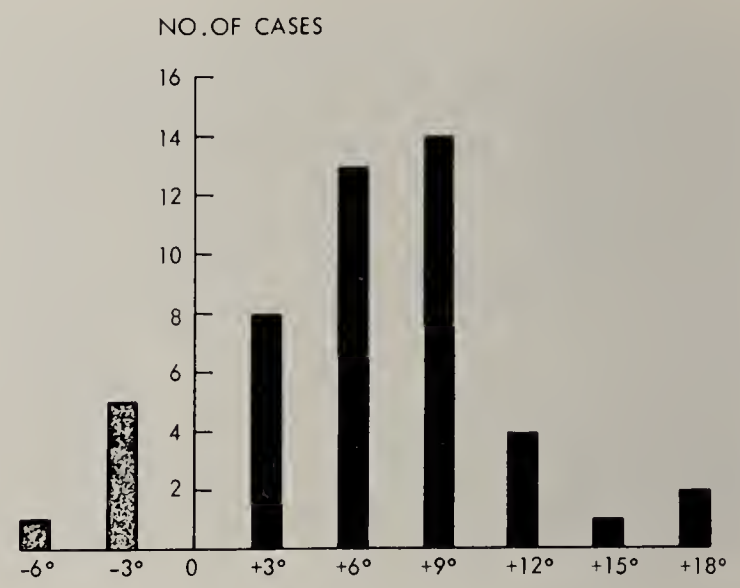


Fig. 6.—Changes recorded in the angulation of the maxillary central incisors following appliance therapy. Measurements recorded from lateral skull radiographs.

1. The Total Change in the Angulation of the Incisor Teeth during Appliance Therapy

a. Results from Lateral Skull Radiographs

Fig. 5 shows the effect of the appliance therapy on the angulation of the mandibular incisors. Predominantly, there was a retroclination of the mandibular incisors. In 33 cases they retroclined between 3° and 15° and in another 8 cases the retroclination was greater than 15°. In 3 cases the lingual tilting of the lower incisors was 3° or less and, finally, in 4 cases the cephalometric measurements indicated small degrees of proclination up to 3°, but such measurements may be open to question regarding their accuracy.

The changes recorded in the maxillary incisors (*Fig.* 6) were that 27 cases exhibited a proclination of from 3° to 12° whilst in 7 cases the proclination was greater than 12°; but in 8 cases the proclination was small, being only 3° or less. Finally, in 6 cases small degrees of retroclination were observed. However, once again these figures were relatively small and in certain cases might have been due to errors inherent in the cephalometric measuring technique.

b. Results from Orientated Study Models

In this group of 11 patients a similar pattern of mandibular incisor retroclination was observed, ranging from 6° to 17°. However, in this limited experimental group no evidence was obtained of any proclination of the mandibular incisors.

Fig. 7 shows a typical pattern of measurements obtained from 1 of the 11 patients. A series of 4 orientated study models was recorded at intervals before treatment and you will notice that all of these measurements fall close together, so forming a base line, against which all future measurements can be compared. Occipitomental traction was commenced in this case at the tenth week and further orientated impressions were obtained at regular intervals. The graph indicates a progressive retroclination of the mandibular central incisors up to 13° by the time that appliance therapy was stopped after 14 weeks. Thereafter, there was a typical slight decrease in the amount of retroclination, but the corrected relationship of the incisor teeth has remained clinically stable for 3 years.

In this particular patient, the maxillary incisors showed a slight degree of proclination with a maximum change of 4° to 5°. Measurements obtained from the maxillary and mandibular lateral incisors showed a very similar pattern and amount of tooth movement (*Fig.* 8) to that recorded for the central incisors.

Fig. 9 records the cephalometric analysis of the same patient before and at the end of treatment. In this instance, the total change in the angulation of the incisor teeth at the end of appliance treatment recorded by this method agrees closely with the figures obtained from the orientated study model method. This is particularly so in the case of the mandibular incisors.

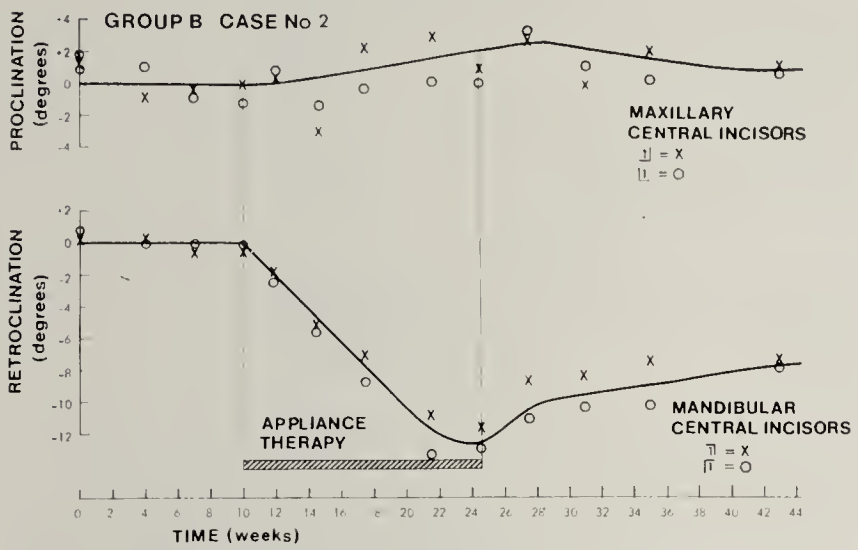


Fig. 7.—Graphic presentation of measurements of the angulation of the central incisors recorded from serial orientated study models. Group B, *Case* 2—a 13-year-old boy.

Table II shows the result, and the bottom line indicates that there was an average weekly retroclination of 1·01° for the mandibular incisors and an average weekly 0·5° proclination for the maxillary incisors.

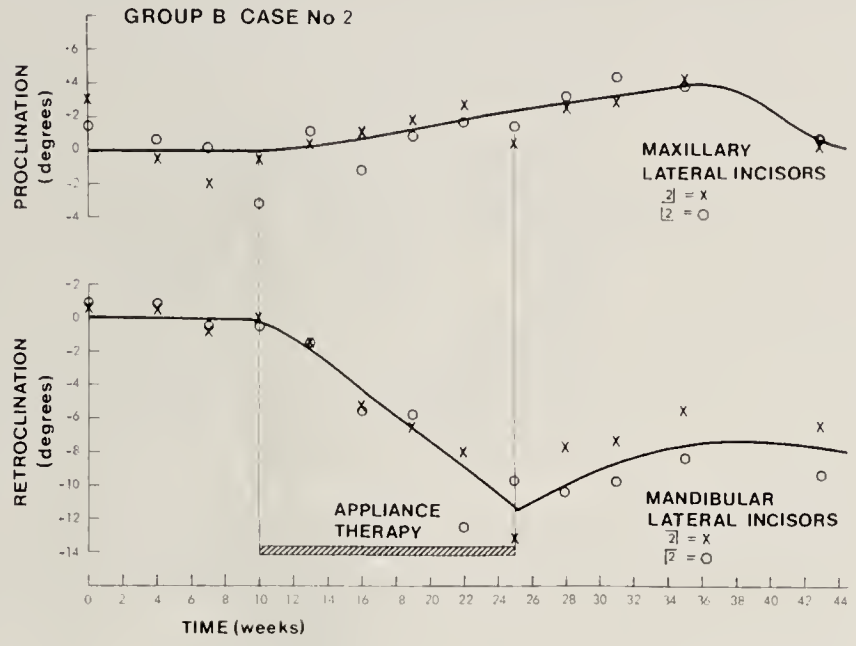


Fig. 8.—Graphic presentation of similar measurements from the lateral incisors of Group B, *Case* 2.

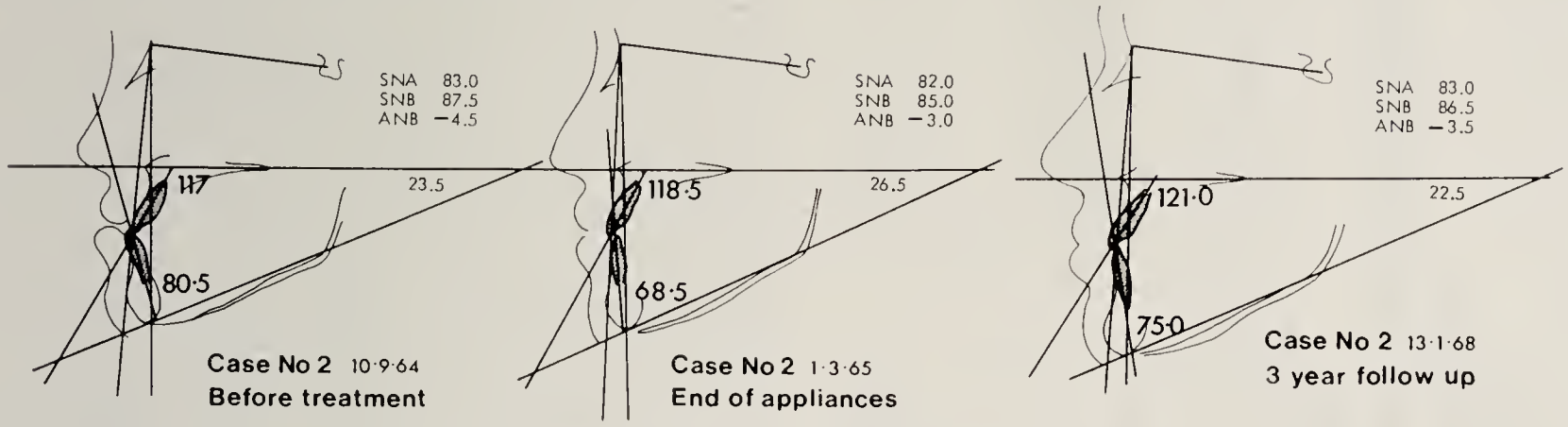


Fig. 9.—Cephalometric analysis of Group B, *Case* 2.

Generally the Group B patients showed a similar pattern of measurements for the maxillary incisors. In 10 cases the average total proclination was 5·5° (range 0·5° to 12°), but in 1 case the orientated study model method recorded a repeated retroclination of the maxillary incisors during the period of appliance therapy (*Fig*. 10). In this case the cephalometric analysis (*Fig*. 11) produced a confirmatory set of measurements as the maxillary central incisors appeared to retrocline by 6° during appliance therapy. Unfortunately, I cannot provide any explanation for this trend, but the persistent negative measurements recorded by both measuring techniques would seem to indicate that this was what occurred.

2. The Rate of Change in the Angulation of the Incisor Teeth produced by Occipitomental Traction

Measurements obtained from the orientated study models at frequent intervals during appliance therapy permitted the rate of change to be recorded for each Group B subject.

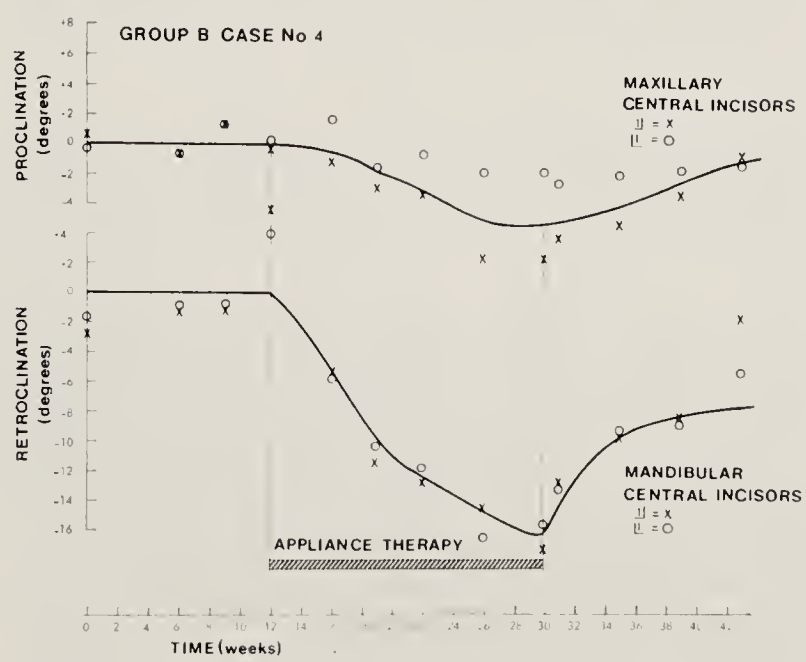


Fig. 10.—Graphic presentation of measurements from serial orientated study models of Group B, *Case* 4. A consistent pattern of retroclination of the maxillary incisors has been recorded during the period of appliance therapy.

3. The Duration of Active Appliance Therapy

The period of 3–6 months was the most frequent time required to produce a correct incisor relationship and 29 cases were completed within this interval (*Fig.* 12). In 8 cases a normal relationship was obtained in less than 3 months, positive overjet or normal incisor relationship was produced at the end of appliance therapy, and in the remaining 6 cases (12·5 per cent) an edge-to-edge incisor relationship was achieved.

The long-term effects, obtained after an average follow-up period of 2 years 11 months

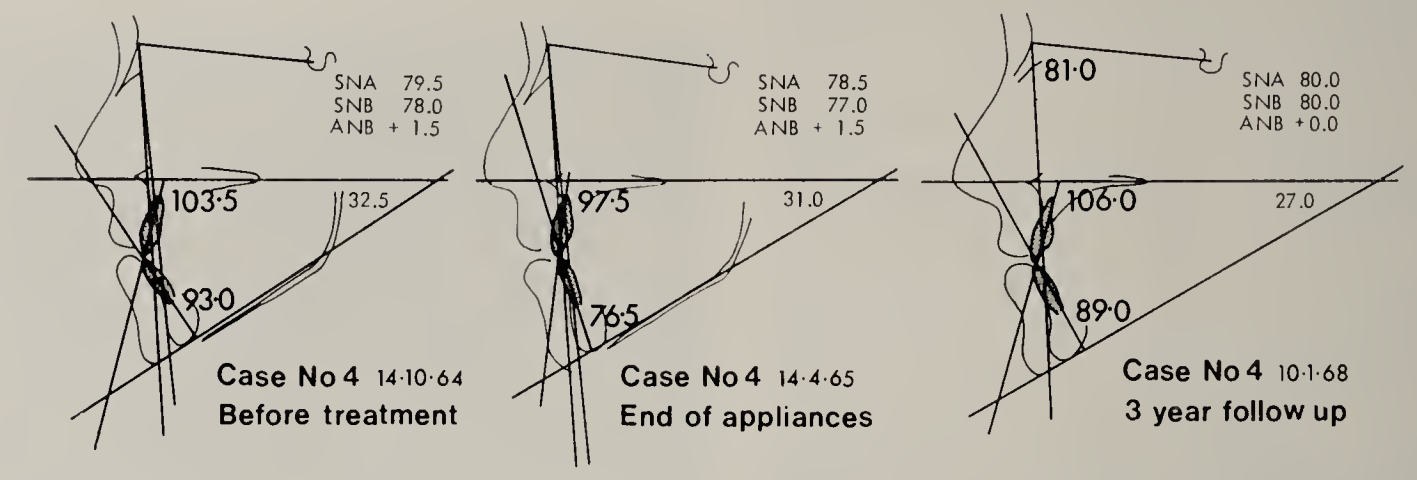


Fig. 11.—Cephalometric analysis of Group B, *Case* 4. This also indicates that maxillary incisors tilted palatally during appliance therapy.

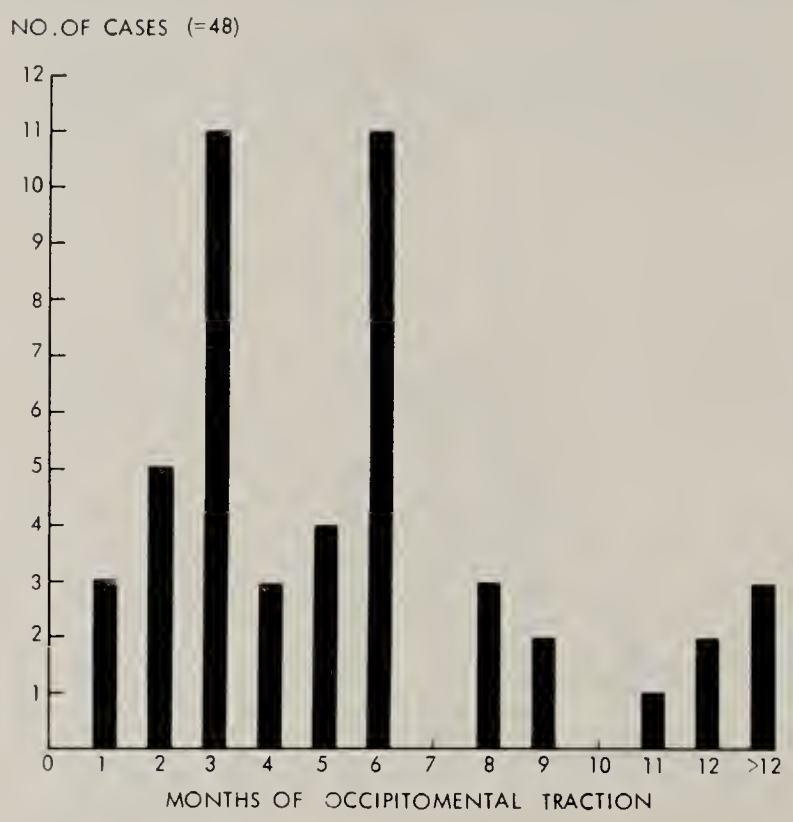


Fig. 12.—Duration of reinforced occipitomental traction employed in the treatment of 48 patients affected with Class III malocclusions.

Table II.—The Rate of Change in the Angulation of the Incisor Teeth following Reinforced Occipitomental Traction. Based on Measurements from Serial Orientated Study Models

	Rate of Change Produced by Occipitomental Traction	
Group 'B' Cases	*Mandibular Incisors*	*Maxillary Incisors*
Case 1	1·14°	0·36°
Case 2	1·00°	0·14°
Case 3	0·83°	0·63°
Case 4	1·00°	0·50°
Case 5	0·64°	0·75°
Case 6	1·37°	1·40°
Case 7	1·80°	0·50°
Case 9	1·00°	0·25°
Case 10	0·75°	0·25°
Case 11	0·75°	0·25°
Average weekly change	1·01°	0·50°

whilst at the other extreme 8 cases required 8–12 months of appliance therapy. Finally, in 3 cases treatment was continued for longer than 12 months.

It must be mentioned that in many instances a normal incisor relationship was produced in shorter periods of time than indicated by the present figures. However, quite frequently appliance therapy was continued in the hope of producing a more stable result.

4. The Effect of this Therapy on the Incisor Relationship

Table III illustrates the short-term effect of appliance therapy. In 42 cases (87·5 per cent) a with a range of 2 and $4\frac{1}{2}$ years, were somewhat different.

In 28 cases (58 per cent) a positive overjet was still present after 3 years, but the number of cases with an edge-to-edge relationship had increased to 12 patients (25 per cent) whilst in 8 cases (17 per cent) a complete relapse had occurred in the relationship of the incisor teeth.

FURTHER OBSERVATIONS AND CONCLUSIONS

The material was collected from patients referred to the Newcastle Dental Hospital and, as far as possible, cases in which it was considered

that the reversed overjet could be corrected with a simple maxillary appliance were excluded from the study. However, the material includes some cases with marked skeletal prenormalities and assessed clinically as cases of dubious prognosis.

Table III.—The Effect of Reinforced Occipitomental Traction on the Relationship of the Incisor Teeth

	Positive Overjet Achieved	Edge-to-edge Relationship	Complete Relapse
Short-term results	42 Cases (87·5 per cent)	6 Cases (12·5 per cent)	Nil
Long-term results (Out of retention 2 years 11 months)	28 Cases (58·0 per cent)	12 Cases (25·0 per cent)	8 Cases (17·0 per cent)

Although it was not a primary aim of this investigation some analysis of skeletal measurements (*Table IV*) was undertaken and the results revealed a similar pattern of figures to those reported by Mills (1966). In my material only 2 cases had a normal skeletal pattern when assessed by the A.N.B. angulation, and this corroborated the findings of previous investigators that in Class III malocclusions there is an overwhelming predisposition towards a prenormal skeletal pattern (Björk, 1947; Maj, Luzi, and Lucchese, 1958; Braccesi and Lucchese, 1958; and Hopkin, 1962). In the present material no significant change in the skeletal angulations was observed following the course of active appliance therapy. However, a slight increase of 0·58° was recorded in the maxillary-mandibular angle at the end of appliance therapy, but after the 3-year follow-up period this angle had decreased by 1·37° and these figures confirm the observations of Hopkin (1962).

During this investigation 48 of the 50 patients wore this appliance each night and generally the tolerance and co-operation of these young children were excellent. No complaints were heard regarding excessive tension from the elastic bands and no pain or discomfort was noticed in the temporomandibular joint region. Twelve per cent of the cases suffered from a mild sweat rash in the area of skin covered by the chin-cap, but this would be minimized by lining the chin-cap with boracic lint or plain gauze.

The results have indicated the effect of this appliance on the incisor teeth, and it would appear that the non-radiographic study model method can be a useful adjunct to the time-honoured method of cephalometric analysis, especially when frequent measurement of the incisor teeth is required during short intervals of time.

We have seen that occipitomental traction predominantly produces a rapid retroclination of the mandibular incisors and an effective, but less marked, proclination of the maxillary incisors. Mills (1966) concluded that the best treatment for Class III malocclusions would seem to be to procline the upper incisors and simultaneously to

Table IV.—Assessment of Skeletal Pattern

Present Investigation

Angulation	Before Treatment (48 cases)		After Treatment (48 cases)		Long-term Change (43 cases)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
S.N.A.	79·52	2·41	79·06	3·75	78·62	4·11
S.N.B.	80·73	4·45	79·91	3·90	80·30	4·15
A.N.B.	–1·45	2·62	–0·84	2·50	–1·66	2·28
Max-Mand.	29·42	4·85	29·99	5·02	28·62	5·51

Comparative Figures from Mills (1966)

Angulation	Before Treatment (44 cases)		After Treatment (44 cases)		Long-term Change (44 cases)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
S.N.A.	78·85	3·22	79·18	0·72	79·45	1·32
S.N.B.	80·70	3·15	80·26	1·03	81·12	1·46
A.N.B.	–1·77	2·59	–0·90	1·07	–1·51	1·20
Max-Mand.	27·28	5·45	27·81	1·51	26·14	2·89

retrocline lower incisors, and I would contend that reinforced occipitomental traction is 'one' method of achieving this aim.

This technique may have certain advantages, as the appliance is simple to construct, no special apparatus is required, and the patient only has to wear it at nights. Also, in young children, even if the lower first molars are present and adequately erupted it is often difficult to retain a removable appliance satisfactorily. Finally, in clinical practice this type of appliance can be especially useful in cases where lower first permanent molars have been extracted and no posterior teeth exist for

retaining a removable or fixed mandibular appliance.

SUMMARY

Fifty children with Class III malocclusions were treated by reinforced occipitomental traction. At nights only, they wore a removable maxillary appliance connected by elastics to an acrylic chin-cap which was secured to a simplified head gear.

Initially, a correct relationship of the incisor teeth was obtained in 87·5 per cent of cases after an average period of 3–6 months appliance therapy. Subsequently, after a follow-up period of 3 years, the number of cases with a normal incisor relationship had decreased to 58 per cent.

This treatment produced a rapid retroclination of the mandibular incisors and a less marked proclination of the maxillary incisors. The changes in the angulation of the incisor teeth were recorded from cephalometric analysis and from a new orientated study model method and special vernier measuring apparatus.

Acknowledgements

I wish to acknowledge my indebtedness to Mr. M. A. Kettle for introducing me to this appliance and for so much helpful advice. I would also thank all my orthodontic colleagues at the Newcastle upon Tyne Dental Hospital for their co-operative assistance, and Mr. F. C. Smales for all the statistical analysis. I wish to thank Mr. Brian Hill for the illustrative material and Mr. J. Watson for taking the cephalometric radiographs.

This work has been generously supported by a grant from the Research Funds of the United Newcastle upon Tyne Hospital.

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DISCUSSION

Mr. H. L. Leech said that he was not clear whether Mr. Bennett carried out any extractions in the lower arch in these cases. In the cases where he did not do so, did the retroclination of the lower incisors result in their imbrication. Also, at the end of treatment, did he find any traumatic occlusion between the upper and lower incisors?

Mr. D. T. Bennett said that he had not noticed any cases of traumatic occlusion following treatment. However, in about three cases in the present investigations some resorption had been noticed on the roots of the incisor teeth on the original X-rays prior to active treatment. The patients were mainly in mixed dentition cases and would probably have had their lower deciduous molars out before appliance therapy, for example, the first case in the paper which illustrates the orientated study model records of a 13-year-old boy. He had a large mandible with plenty of spacing and the premolars were unerupted when he was first given the chin-cap and no imbrication was noticed afterwards.

Mr. J. D. Muir said that he could not see that occipitomental traction was going to limit the growth of the mandible very much unless it was used for an excessive portion of the day and with excessive force, in which case he supposed it might produce a little deformity along the lines of binding a Chinese woman's foot. He did not see why it should produce a slightly miniaturized yet morphologically perfect mandible.

With regard to the other part of the appliance, the elastics from the chin-cap, he could not really see that this did much in retroclining the lower incisors and bringing forward the upper teeth that would not be achieved by routine Class III intermaxillary traction.

Mr. Bennett said that when he went to Newcastle $5\frac{1}{2}$ years ago, one of his colleagues had said that the children would not wear this type of appliance, but they did wear it! After all, this was the Space Age! It was a matter of how it was put over to them.

Many patients in the North East certainly did not have lower first permanent molars, so you could not use fixed or removable appliances. The appliance des-

cribed certainly did retrocline the lower incisors. He had not tried to investigate the skeletal changes, but he did not believe that in the short period of time he gave this appliance to patients (3–6 months) that it had any effect in limiting mandibular growth. However, Janzen and Bluher had produced evidence that, in monkeys, the skeletal pattern could be altered with a simple chin-cap.

Mr. P. R. W. Coyle asked what force was used with the elastics and for how long were the patients instructed to wear the appliance per day.

Mr. Bennett replied that patients tolerated very well an elastic which was double its original length when it was under tension. He found it easier to teach students something like this, than figures in grammes or ounces.

Concerning hours per day, this depended on the children, but it was certainly about 8 hours a night. It was not worn during the day at all. Usually, patients did not wear the intra-oral appliance either during the day.

Mr. B. H. Miller asked if any posterior capping or bite raising was incorporated in the upper appliance, and whether, if not used, this might have an effect on the proportion of change in angulation in the upper and lower incisors, perhaps also accounting for the retroclination Mr. Bennett found in the two cases in the upper incisor region.

Mr. Bennett replied that no capping or bite raising was used at all.

Mr. J. R. Pettman said that one complication he had found in using this appliance was that the lower gingiva occasionally began to flatten and affect the labial surfaces of the gingivae between the lower incisors. This was a little troublesome and necessitated special care. Occasionally, he thought the lower labial segments began to flatten somewhat, the lower canines being left rather at the corners of an arch instead of being part of an arch itself.

Mr. Bennett replied that he had not observed the canines being more prominent. He had only seen one case in his experience—he was not sure if it was in this group—in which the gingiva deteriorated and a week's rest seemed to sort it out.

Mr. R. A. Campbell said that he was interested to note that the technique when correcting the reverse incisal relationship was mainly by retroclination of the lower incisors rather than proclination of the upper incisors. The upper appliance acted on the whole arch, but the lower only on the incisors. Would there be any point in modifying the upper appliance to give additional force on the upper incisors only.

Mr. Bennett replied that in cases where he felt he needed everything he could give the patient to correct the incisor relationship, he would use additional screws and springs.

He said that the effect of the appliances he used seemed to be twice as great on the lower teeth as on the upper.

Mr. C. P. Briggs, referring to Mr. Campbell's point, said that in his experience, if an attempt was made to procline the upper incisors too rapidly and too far, the end result was an anterior open bite.

THE POTENTIALITIES OF THE UNIVERSAL BRACKET

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Consultant Orthodontist, Newcastle Regional Hospital Board

It is accepted that in orthodontic treatment appliance technique is secondary to the analysis of the individual patient's morphology and treatment requirement, and further in this country it is thought that no single appliance system is suitable for all cases. Many patients' orthodontic requirements can be satisfactorily met with

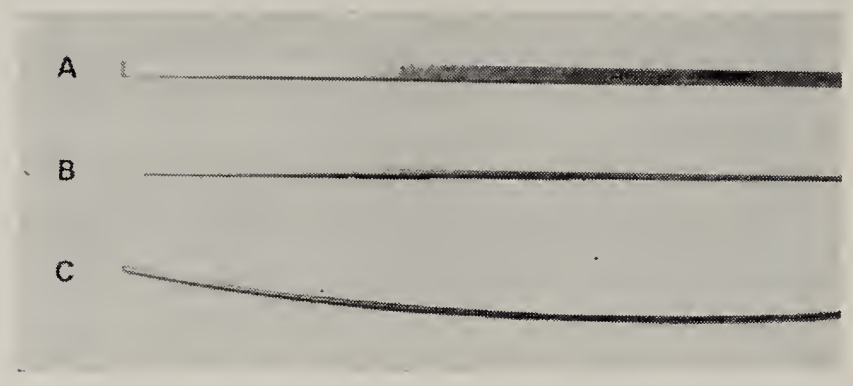


Fig. 1.—Universal arch wires; A, B, the two dimensions of the ribbon arch (0·028 × 0·012 in.) C, The round wire (0·014 in.).

interceptive measures, and many more by treatment with removable appliances. There is, however, also a proportion of cases which requires fixed appliances of varying complexity, and there is a continual search for the best approach in this group.

The most frequently used fixed appliance in this country is possibly the twin-wire arch and ripple-bracket system, and many of us have a lasting attachment to this mechanism. A requirement still exists for an even more versatile appliance, and both the edgewise appliance and the various round wire systems culminating in the Begg light wire technique have their devotees. Magnificent results are possible with both methods, but for the best results a complete allegiance to the appliance and even the acceptance of a standard view on diagnosis is demanded. It is not intended to discuss the respective merits of the various fixed techniques in use, but to suggest that there may be room for a technique capable of both dealing with the most difficult orthodontic problems and yet of being integrated into the varied treatment requirements of orthodontic practice in this country.

To this end I should like to draw your attention to the Universal system of appliances; not a new system, but one in use for over 30 years in various parts of the U.S.A. Spencer Atkinson, the originator of the system, is one of the father figures of American orthodontics, well known already in this country for his studies in facial morphology, but little attention so far has been given to his appliance designs. The Universal system was one of the first appliances designed to produce light and near physiological forces to obtain optimum tooth movement without damage to the dento-alveolar tissues. The history of the development of the Universal bracket is well covered by Yudelson (1967) and his account of the present-day treatment procedures with the Universal appliance is worthy of close study. The clinical acumen of Spencer Atkinson is shown by his illustration in 1937 of perverted swallowing as a cause of anterior malocclusion, and his appliance system is even now increasing rapidly in popularity in spite of competition from appliances introduced more recently, some of which have been already discarded in the intervening time.

The components of the system will be systematically described starting with the arch wires which are two in number (*Fig.* 1). The ribbon arch is 0·028 in. wide (*Fig.* 1A) and 0·012 in. thick (*Fig.* 1B) and is soft enough to be readily adapted to the desired arch form, yet retains a considerable degree of springiness in the plane of the tooth surfaces. A high-tensile round wire of 0·014 in. (*Fig.* 1C) is also available for the majority of tooth movements and can be used in the form of a light wire system (0·016 in. is accepted by the latest brackets).

The key to the appliance system lies in the bracket design. The double-action type (*Fig.* 2A) is the basic form and features an occlusal vertical slot for the ribbon arch, and a gingival opening for the round wire, which are locked into the brackets by pin placement. There are mesial and distal tabs separating the two arch wires and with this combination tooth movements in all three planes of space are available. This is the origin of the term ' Universal ' for the bracket and there

Presented at the meeting held on 8 January, 1968.

is no conceit that all malocclusions are amenable to treatment.

From the double-action bracket a family of lesser brackets is derived, two of which are the root torquing type (*Fig.* 2B) with eyelet tabs for rotations and a smaller bracket for narrow teeth (*Fig.* 2C). Examples of molar attachments

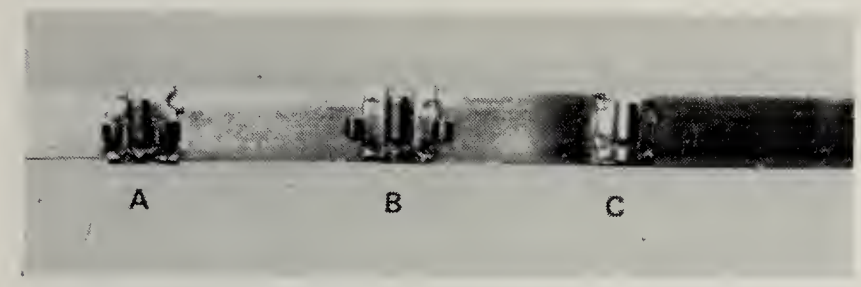


Fig. 2.—Varieties of Universal bracket. A, Double action type. B, Root torquing type. C, Small bracket.

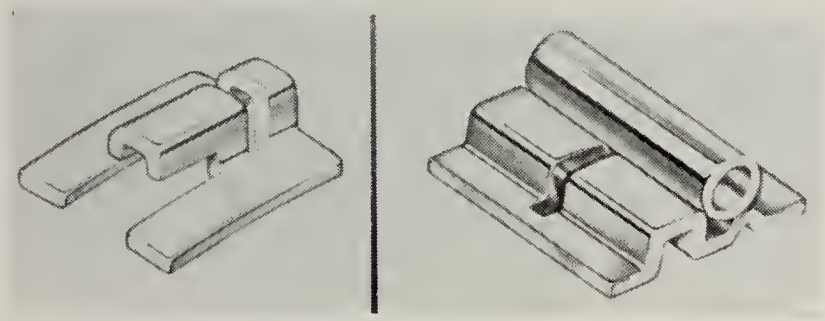


Fig. 4.—Universal bracket and molar sheath. (*Reproduced by kind permission of the Unitek Corp.*)

which again receive the ribbon arch occlusally and the round wire gingivally are shown (*Fig.* 3A). First, the long double buccal sheath and secondly (*Fig.* 3B) the same attachment manufactured with an attached tube to accommodate occipital traction auxiliaries. Further (*Fig.* 3C), there is a lingual attachment accommodating a redoubled end of a lingual or palatal arch of 0·036 in. This provides an excellent removable arch for auxiliary springs or for the prevention of molar rotation. A diagrammatic presentation of one form of Universal bracket and a representative molar sheath are shown in *Fig.* 4.

Coil springs play an important role in this system. The standard coil 0·010 in. on 0·03 in. arbor (*Fig.* 5A) will slide freely on the ribbon arch as a push coil. An eyelet compression coil (*Fig.* 5B) is used as a pull coil for retracting individual teeth, particularly canines. A Phetcher type pull coil can be useful (*Fig.* 5C), and for retraction of the labial segment a double-contraction coil construction (*Fig.* 5D) is available. The construction of coil springs is covered in articles by Nagamoto (1943) and Adams (1955).

A construction on tape is shown for several methods of applying apical torque. Torque in the mesiodistal direction is simply produced by the angle of the bracket (*Fig.* 6B) and activating the round wire. A simple whip can be also placed (*Fig.* 6A) for the same purpose, when more power is needed. Labiolingual torque is most simply available by angulating the ribbon arch (*Fig.* 6C), and such torquing bends can be simply made by Howe's or any other flat-nosed pliers and the ribbon arch has then a sufficient springiness to be pinned into place to induce the required apical movement. If desired as an alternative a torquing

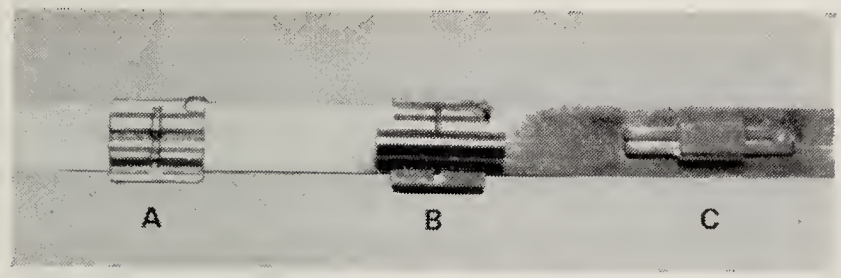


Fig. 3.—Universal molar sheaths. A, Long double buccal sheath. B, The same with a third tube to accept extra-oral bow. C, Lingual attachment to accept redoubled end of lingual arch.

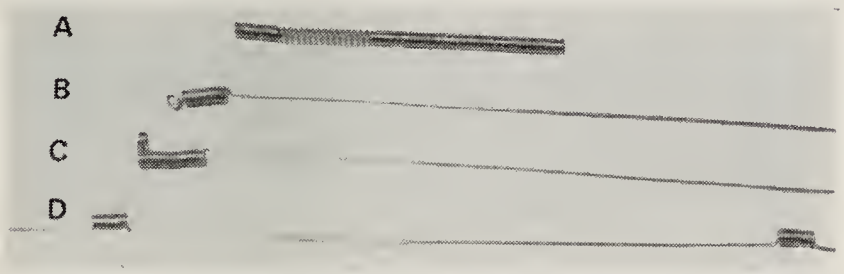


Fig. 5.—Coil springs used in the Universal appliance. A, Standard coil. B, Eyelet coil used as ' pull coil '. C, Phetcher type of ' pull coil '. D, Double contraction coil.

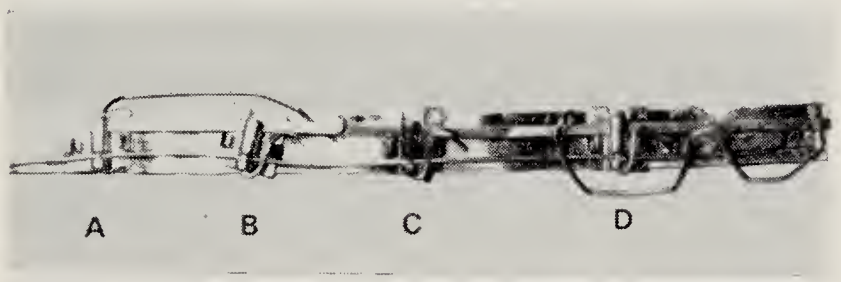


Fig. 6.—Methods of producing root movement shown on tape construction.

auxiliary can be used as with other techniques (*Fig.* 6D).

With respect to the clinical application of this appliance the literature yields useful articles by Bowden (1942), Erikson (1942), Waldron (1943), Day (1951), Parrot (1958), and, more recently, Cucalon (1965) and Yudelson (1967) provide considerable clinical detail of the practical aspects of the full-banded case. In some respects perhaps the initial appearance of the full-banded case with this technique may be intimidating to British eyes and perhaps may precipitate an initial adverse reaction such as, ' I have enough problems with one arch without getting involved with two '. It may therefore be of value if I show a short selection of simple applications of the technique; both to illustrate the advantages of the Universal bracket in clinical use, and to also remove the impression that the technique is unnecessarily complex.

Indeed Spencer Atkinson (1937) introduced the appliance originally as a sectional appliance for distal movement in the buccal segments so there may be some justification to my approach.

One of the simplest, but most useful, applications is in the reciprocal approximation of two teeth as with the closure of a median diastema which proceeds in a well-controlled manner with

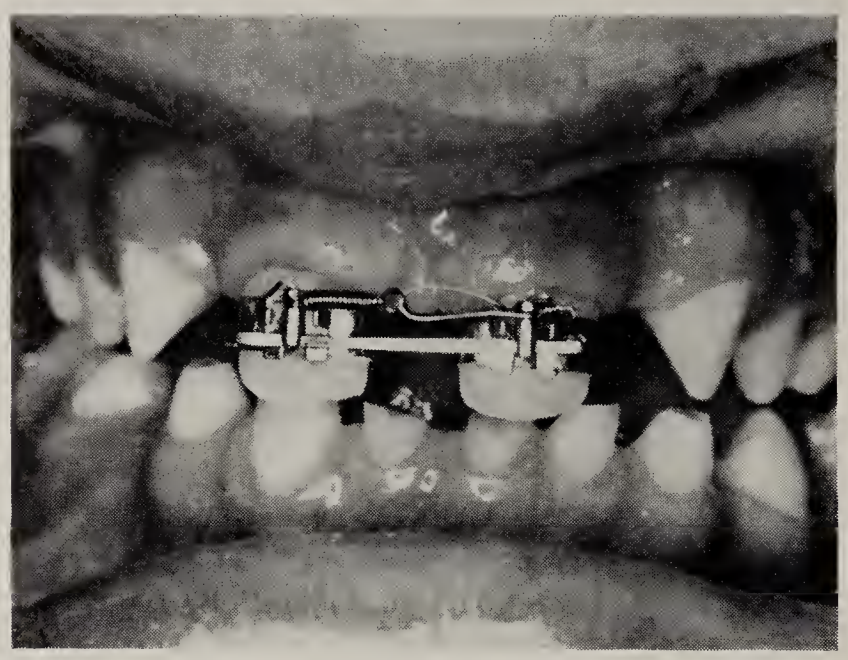


Fig. 7.—Universal sectional arch to approximate $\underline{1|1}$.

Fig. 9.—Sectional appliances to retract upper and lower left canines.

a Universal sectional arch. A case of partial anodontia (*Fig.* 7) which will require a prosthesis following approximation of the central incisors is shown. The single eyelet contraction spring provides a force acting above the ribbon arch wire, reducing tilting of the central incisors to a minimum while gently but positively closing the median space.

A further application in sectional form (*Fig.* 8) shows two associated, but independent, tooth movements being undertaken. An unerupted upper central incisor has been surgically exposed and the appliance is capable of both opening a sufficient space by moving apart the incisors while applying an axial force on the central incisor. Many cases require canine retraction and it is shown in *Fig.* 9 the most frequently used method of canine retraction with the Universal system when tilting is to be avoided. The single eyelet spring is pinned into the gingival slot and activated by tying back posteriorly. The bracket design also allows it to be soldered to a cast cap if

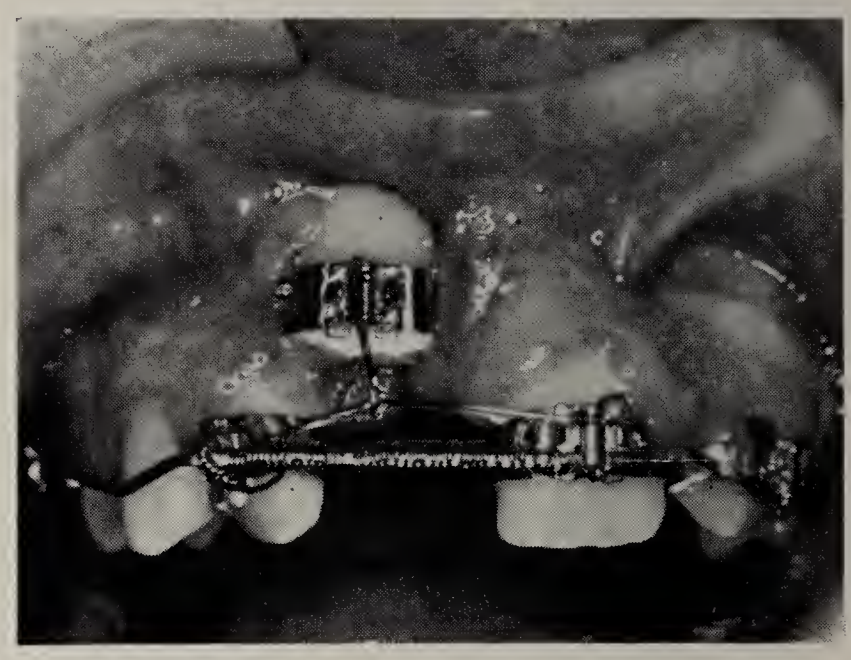


Fig. 8.—Universal sectional arch to open $\underline{2|1}$ space and aline $\underline{1|}$.

the gingival level on the palatal aspect of the canine rendered band construction difficult, as was the case with the upper sectional appliance.

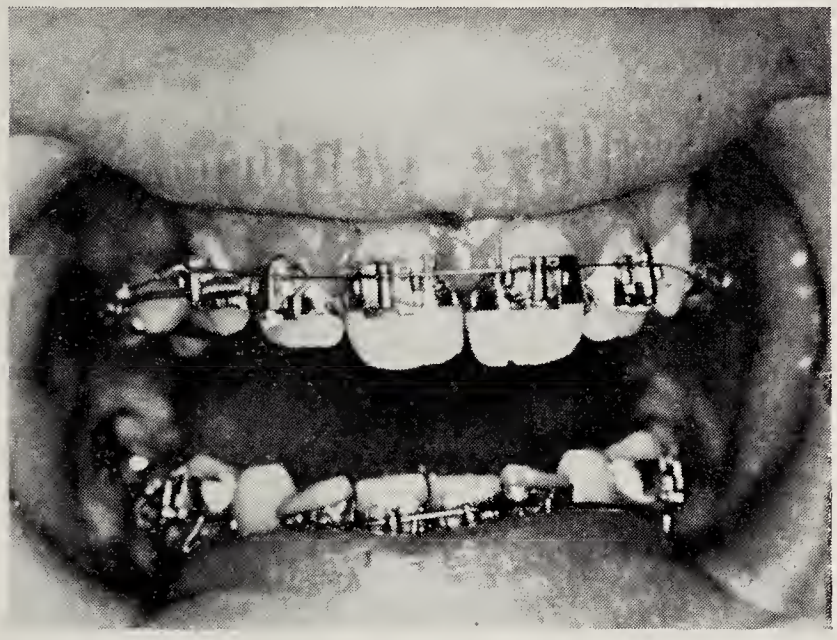
A case of a severe distocclusion with extreme overjet and deep overbite (*Fig.* 10A) illustrates a further stage in the use of the appliances. Routine canine retraction after extraction of first premolars was undertaken with eyelet retraction coils tied back on both sides, and the $\underline{3|}$ is being retained with a ribbon sectional. The lower incisors are being depressed and spaces closed with a 0·018 in. round wire pinned into the occlusal channels. After correction of the incisor relationship by retraction with double retraction coils to the optimum (*Fig.* 10B) retention was continued with 0·014 in. archs placed in both channels of the brackets of each arch after adaption to a reverse bend of Spee to level the occlusal plane as far as possible, and the casts of the result are shown (*Fig.* 10C). There are orthodontists with a reluctance to use multiband techniques, and one argument used is that there may be an adverse effect on the gingival state of the patient. Fortunately, routine periodontal assessments are available for this case before and after treatment and are reproduced to provide reassurance on this point.

CASE REPORT

The patient, a girl of 14 years, was examined on 14 March, 1966, before active orthodontic treatment was begun, and a periodontal assessment was made. The findings were that she had fairly good oral hygiene with a Green's O.H. Index of 6. Her gingival

condition was good with pale pink, firm, and stippled gingivae. There was very slight pocketing of 1 mm., which was generalized. $\overline{21|12}$ were slightly mobile and $\overline{|5}$ was a stagnation area. Her lips were incompetent. The periodontal assessment of her mouth was repeated on 3 Jan., 1968, when active orthodontic treatment was completed. Her oral hygiene was found to be of the same standard, i.e., Green's O.H. Index of 6. The patient's gingival condition showed no

A



B

C

Fig. 10.—A Class II, division 1 case. A, Before treatment; B, With Universal appliances in place; C, Casts taken before and after treatment.

obvious changes whatsoever, and her mouth was healthy with no signs of gingival inflammation. Her gingivae were firm and stippled. There was 1 mm. pocketing generalized, and $\overline{21|12}$ were still slightly mobile, but neither of these factors had worsened during the period of active orthodontic treatment. She had no stagnation areas in her mouth, the instanding $\overline{|5}$ having been extracted. Her lips were now competent.

CONCLUSIONS

This completes a short series of cases shown to illustrate a few only of the varieties of appliance design allowed by the inspired design of the Universal bracket. It is hoped that the reader will now benefit from a study of the literature on the full banded technique. As it is felt that the Universal appliance system is particularly suitable to play a role in British orthodontic practice some of the advantages of the method are thought worth tabulating.

1. An individual approach to diagnosis and treatment required is possible and both extraction and non-extraction procedures are equally well undertaken.

2. The anchorage control through the ribbon arch is excellent as is space maintenance following extractions.

3. Unwanted reciprocal movement of adjacent teeth during tooth movement can be readily avoided.

4. Both local sectional appliances and the full-banded techniques are available.

5. The design of the bracket allows all varieties of tooth movement to be obtained with relative ease.

6. There is relatively little complex wire bending needed and arch wires can be changed quickly on the rare occasions when necessary.

7. The appliance is unusually strong and resistant to patient interference in its full-banded form.

8. Frictional resistance to tooth movement is low due to pin location of arches.

9. Provision is available for extra-oral traction, intermaxillary traction, and there is also a lingual arch system.

10. The system need not be used exclusively, but as an addition or in combination with techniques that are presently found useful by the individual orthodontist.

Acknowledgements

My thanks are due to Miss C. Dixon for the periodontal report, and also to Mr. N. Stainsby for the photographs. I am indebted to Dr. R. Yudelson and Dr. R. Gawley for their help and encouragement in developing an interest in this technique.

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DISCUSSION

The President thanked Mr. Dixon for a very clear exposition. He said that the Universal appliance was one of those things he had met in books only until this meeting. He asked if the ribbon arch was shaped before the spring was inserted in place.

Mr. Dixon said that he found it could be bent quite readily with the fingers to the arch form and, unless torquing bends were required, very little wire bending was needed.

Mr. N. K. Hill asked what metal the cast cap was made of so that Mr. Dixon could solder to it a presumably stainless-steel bracket.

Mr. Dixon replied that it was a silver cap and a low fusing alloy solder.

Mr. F. Allan said that the main objection to the Universal appliance was the same as the objection to every fixed appliance: it was a friction technique and used torque. Apart from friction, torque was another bad thing which nobody had mentioned. The same movement could be done without torque and without friction.

Mr. Dixon suggested that many people did not have the patience and skill to use removable appliances for difficult tooth movements and that fixed appliances were then required.

Mr. J. D. Muir said that the Universal bracket would seem to have neither the precision of an edgewise attachment nor the cheapness of a ripple bracket. He could not see that it had any great advantage over the free tipping properties which the Begg bracket already allowed.

He had two questions: how were rotations usually handled and what was the cost of the bracket?

Mr. Dixon replied that the cost of the bracket was in the region of 3s. 6d. The full-banded case would come to about £3–£4. He thought that, in terms of clinical time, this was justified, in that a difficult case could possibly be treated in a shorter time and, therefore, greater economy with this type of fixed appliances.

With regard to rotations, one of the brackets he had shown in passing was adapted for rotation with little spurs on the edge of the bracket which could be ligated to the round wire. If necessary a Steiner rotation wedge auxiliary could be used for extreme rotations. He would wish to refute the suggestion that the Universal appliance was not a potentially precise technique and considered that this quality lay more usually with the clinician than with any single appliance.

Mr. L. H. Schuler referred to one of Mr. Dixon's cases with a double protrusion where the angle of the upper incisors was reduced from 120°. He asked if Mr. Dixon had final study models in this case and if there was perfect occlusion and perfect alinement of the posterior teeth. Were they all touching or were there spaces? Was the incisor overlap greater than at the outset or not?

Mr. Dixon replied that he had models of the case but rejected them in favour of X-rays for the presentation. The incisor relationship at the end was normal, he felt, for the case. There was some residual spacing in the lower first premolar region, but he felt that the occlusion favoured closure of the space, without appliances in the lower arch.

Mr. J. R. Pettman said that he was interested in Mr. Muir's comments, but thought that the Universal attachments had advantages. He understood from Mr. Dixon's paper that, whilst the precision bending of edgewise work and Begg arches could be avoided, the relative simplicity of the two arches described by Mr. Dixon could achieve considerable bodily tooth movement. He asked if Mr. Dixon agreed.

Mr. Dixon thought that this was indeed the crux of the matter and in addition, he found that the Universal appliance could be integrated into a personal system of orthodontic appliances, to be applied in the occasional case where it was felt that the round wire arch, as taught in this country, or the twin wire arch, would fail.

AN OCCLUSAL ANALYSIS OF LATERAL MAXILLARY EXPANSION WITH MID-PALATAL SUTURE OPENING

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INTRODUCTION

LABIOLINGUAL movements of the anterior teeth have and will continue to attract most of the attention of both clinician and researcher; there is an obvious aesthetic stimulus to this and we are prepared to accept a buccal cross-bite of the superior instanding type as no particular disturbance of the harmony, either cosmetic or functional. This type of malocclusion was once readily treated by conventional means of expansion, but the passage of time exposed the fallacy of this method in the almost inevitable relapses. These undesirable sequelae led to the abandonment of lateral maxillary expansion except in conjunction with intermaxillary traction as Townend (1955) so aptly summed up in ' The comedy of expansion and the tragedy of relapse '.

The problem of the relatively small maxilla remains, often associated with uni- or bilateral cross-bites, possibly with a reduced overbite and a mild Class III dental base relationship. Such cases may look tantalizingly simple to treat, yet this challenge must be strenuously resisted if only conventional orthodontic therapy is envisaged. If, however, one opts for lateral expansion by spreading the maxillary bones, the likelihood of a stable correction is greatly enhanced.

Now that orthodontics is no longer orientated to the concept of an ideal occlusion with a full tooth complement stabilized by normal function, a number of philosophies discarded in the past are being brought to light and reappraised. Rapid expansion is enjoying a well deserved renascence in Germany, Scandinavia, and America.

ANATOMICAL CHANGES

The rationale of this technique is to maintain a lateral expansive force of such magnitude that widening is dramatically achieved by moving the maxillary bones by sutural adjustments rather than the alveolar remodelling of conventional orthodontic therapy. These extensive anatomical changes have been studied radiologically in man and histologically (especially the sutures) in animals.

The net result is that the maxillary and palatine bones disarticulate from each other and swing laterally apart. The disjunction begins antreiorly

Fig. 1.—Occlusal radiograph at the completion of expansion showing wider opening anteriorly.

at prosthion and moves posteriorly as expansion progresses, with the suture opening throughout its entire length only in very wide expansions (*Fig.* 1). The action of opening is a simple continuous process and such terms as ' bursting ' or ' splitting ' the suture are probably quite inappropriate if a traumatic action is implied. The greater widening anteriorly is due to the bones' free aspect in this area, whilst posteriorly there is heavy buttressing and articulation with other

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bones of the facial skeleton. These are not simple hinge movements but a complex based on multiple fulcra along their articulations with the rest of the facial skeleton, behind and above. This can be reduced to two lines, starting in the zygomatic regions, curving upwards and forwards to converge in the ethmoidal region.

The maxillary teeth, moving with their respective bones, create a median diastema but this soon closes with the calcification of the intersutural space and the pull of the trans-septal fibres, if the centrals are not included in the appliance. More distally, the geometry of the expansion shows itself in the articular change with cross-bite correction. This desirable effect begins with the laterals. The posterior teeth, rotating laterally, increase their axial inclination to the vertical, but later assume an angulation close to their original and constitute a partial relapse.

Sutures which have been histologically studied in the Macaca rhesus monkey (Cleall, Bayne, Posen, and Subtelny, 1965; Starnback, Bayne, Cleall, and Subtelny, 1966) were the midpalatal, frontonasal complex, maxillary-zygomatic, and the zygomaticotemporal. Knowledge of maxillopalatine and sphenopalatine sutures is still very limited. The opening of the mid palatine suture shown radiologically was confirmed together with its mineralization 3 months later; however it was a further 3 months before the suture again showed a normal histological appearance. Adjustments at adjacent sutures were revealed by hyperactivity to a degree directly proportional to their remoteness from the stress of expansion.

Clearly the rapid accomplishment of anatomical change is primarily achieved through sutural activity and secondary adjustments are made by bony remodelling on a long-term basis according to physiological laws and attainment of balance.

EXTRA-OCCLUSAL ASPECTS

Although this paper is primarily concerned with the correction of malocclusion, the extensive anatomical changes incident to the technique call for some reference to the extra-occlusal ramifications if only *en passant*. With the spreading of the maxillae there is an increase in the cross-sectional area of the nasal airway and it requires only a small increase in the lumen to make a substantial improvement in nasal ventilation. Many patients will say that their nasal breathing has improved with a reduction in oral breathing —a fact which has been proved objectively by using pneumatic apparatus (Linder-Aronson and Aschan, 1963; Wertz, 1968).

There is a morphological entity in a narrow maxilla with a measure of nasal stenosis and oral breathing; this stimulated rhinologists to undertake some of the pioneer work. These unfortunate but not uncommon stigmata evoked in some patients can, in certain cases, be quickly and simply relieved by this method. It should be understood that expansions for medical reasons must be wide and may therefore conflict with dental objectives. This paper has perforce been restricted to occlusal aspects.

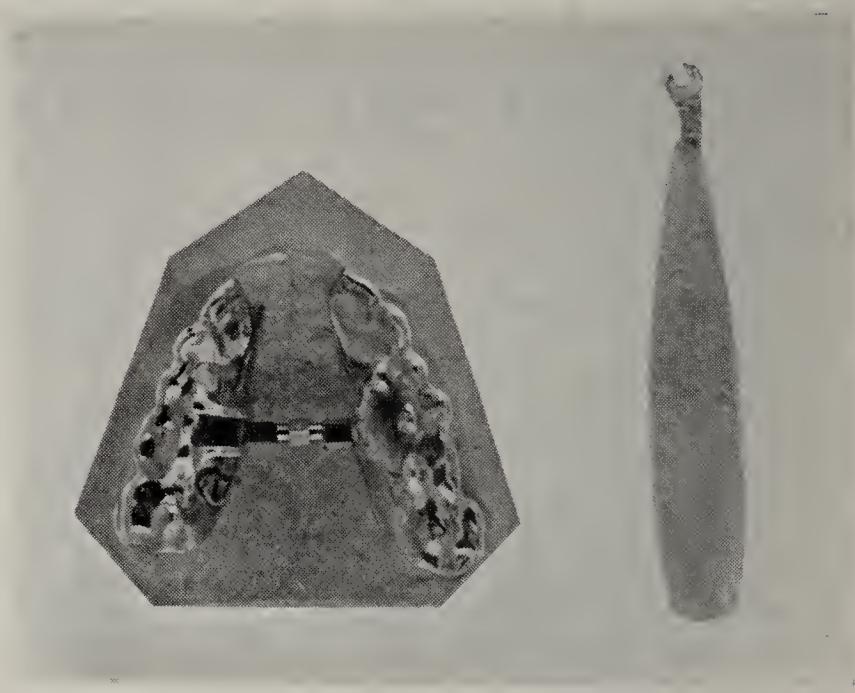

Fig. 2.—Photograph of appliance on maxillary model with spanner.

THE APPLIANCE

There is general agreement amongst operators that the appliance should be fixed, usually banding a premolar and a molar on each side; tags welded to these bands are embedded into a split acrylic base plate which incorporates a conventional orthodontic expansion screw (Derichsweiler, 1956).

On the supposition that the large expansive force will be more evenly distributed amongst the maxillary teeth and therefore reduce damage, the author uses silver cap splints instead of bands, generally from the lateral incisor back to the last erupted tooth. If the anticipated expansion is small, less than 6 mm., a proprietary screw is suitable, connected to the splints by acrylic. The appliance should never be taken completely into the vault of the palate as irritation is sometimes caused. In cases where the required expansion is beyond the range of the screw, substitution of a further screw creates difficulties and here a different form of screw and connexions are used.

Considering the unavoidable rotations involved in the expansion, this is no place for a fully rigid appliance with parallel action which would surely increase the stress in both appliance and human tissues to their mutual detriment and with possible displacement of the cap splints. The appliance is therefore designed with a freely attached screw (*Fig.* 2). To the wax splints, extensions are added to about half the palatal depth in the premolar regions, tapering off anteriorly and posteriorly. Two vertical strips, about 3 mm. high and about 4 mm. apart, are

placed on the deepest part of the flanges to form channels, one of which is covered on the occlusal aspect.

The screw is a Pfaff type (Dentaurum 4b) over which square tubes are soldered to stabilize the female thread. It is then cut and bevelled to fit

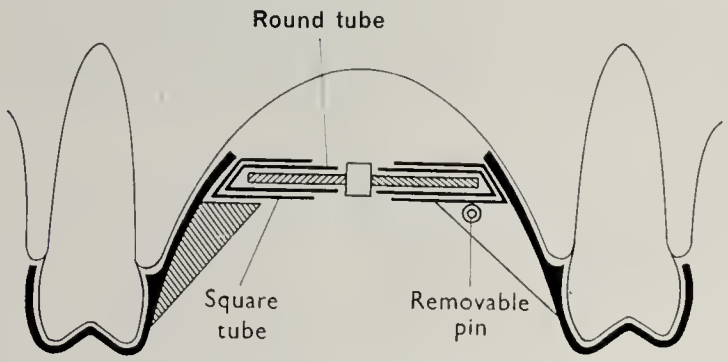

Fig. 3.—Diagram of cross-section through appliance.

in the channels and adjustments to the wax made if necessary. The splint of each side is cast as a single integral unit. Across the non-capped channel, a hole is drilled to receive a pin for retention of the screw, thus constituting the removable factor (*Fig.* 3).

Each splint and screw is an independent unit without rigid fixation between one another; the force of the screw during expansion is exerted merely by butting against the palatal flanges, leaving the teeth and maxillae free to move along their natural expansive paths with minimal constraint.

The thrust exerted by the appliance is the resistance of the maxillae to separate and this results in the build-up of considerable loads as shown by strain gauge experiments (Isaacson, Wood, and Ingram, 1964; Zimring and Issacson, 1965). An expansion of 0·2 mm. (approximately 90° rotation), produced a force of 3–10 lb. depending upon individual factors, chiefly age, the higher figures related to the greater age, groups, no doubt reflecting increased rigidity and decreased elasticity. This load dissipated quite rapidly at first (20–25 per cent in 2 minutes), followed by a progressively slower rate of decay. As the entire load was not dissipated in 12 or even 24 hours, multiple daily activities might result in an excessive accumulation of thrust between the maxillae. Ideally once the optimal thrust is reached it should only be necessary to activate the appliance sufficiently to restore the decay. We do not know the optimal force, but the latitude between the minimum to produce separation and the pain threshold is quite wide. After active expansion it was some 30–45 days before all recordable forces were dissipated.

STUDY MATERIAL

The general observations contained herein were drawn from experience in the treatment of over 100 cases and the background of 100 years of bibliography.

In order to observe scientific protocol and give this paper the required statistical weight, some cases were subjected to biometric scrutiny through their study models. To ensure the validity of the acquired data, selection was based on the following criteria:—

1. Treatment was exclusively by this technique, and no tooth movements being accountable to any other appliance.
2. A minimum of four sets of study models per case, taken at or near the staging points in the treatment, i.e.,
   a. Before expansion.
   b. After removal of splints.
   c. At the end of retention.
   d. Twelve or more months out of retention.

Despite the large number of cases, only 19 fulfilled these minimal requirements, their ages ranging from 10 years to 15 years 3 months. Seventeen were girls and only 2 boys, but no inference should be drawn from this preponderance of females although the total number of cases treated by the author show a ratio of nearly 2:1 against boys.

BIOMETRICS

A series of study models offers the biometrician an *embarras de richesses* but a few recorded teeth movements will suffice to show the changes achieved by this technique. All measurements have been taken from the study models, linear to the nearest half millimetre and angular to the nearest degree.

The first and obvious measurement was the lateral expansion and there, two records were taken:—

1. Between first standing premolars.
2. Between first standing molars.

This was done on both upper and lower study models. The lower to check stability, and here, if any movement occurred, it was to follow the upper with expansion of up to $1\frac{1}{2}$ mm., but some of this was later to be lost. The object of taking two lateral measurements was to demonstrate the prevalence of non-parallel expansion and the differential varied between 0 and 1·5 mm. with the premolar width the greater. The mean of the premolar and molar width increases was taken for analysis, which accounts for the $\frac{1}{4}$ and $\frac{3}{4}$ mm. measurements appearing on the data field.

The maximal and final increases in maxillary width are shown in *Table I* with the percentage relapse. The figure of 41 per cent does not, on paper, speak too highly for the technique's efficiency but this may be misleading and a denigration. The case histories of some of the patients show instances of poor co-operation, where the plate was left out for short periods during the long and critical phase of retention and could only be refitted after trimming. It is probable that a few of the relapses are artificially

and unnecessarily high and more resolute wearing during the phase of removable retention could have yielded a better overall figure. Some workers claim negligible relapses during retention but the literature is conspicuously silent on final relapses.

Next were recorded the angular changes in the longitudinal axis of the first standing molars by grinding the study models vertically through the centres of the teeth and scribing their longitudinal axes with the aid of a crown template. The angles between the axes and the model base can then be measured and the angle between the axes calculated; this angle was used in the analysis (*Fig.* 4).

Despite this crude method of measurement, a consistent pattern of behaviour emerged (*Table II*). The increase in angulation showed a wide variation, not necessarily related to the increase in linear width. This increase would appear to diminish immediately after removal of the fixed splint until it approximated that before treatment, despite the wearing of a removable retention plate, and may be related to the slight linear relapse during this phase. If the inclination is the same with an increase in arch width, can it be assumed an increase in apical width?

By taking a synthesis of the results, an interpretation has been attempted for the pattern of buccal tooth movements over a complete treatment course, by two graphs, one linear and the other angular to the same time scale (*Fig.* 5).

If the primary objective was to correct a lateral cross-bite, one would hardly expect laudable results from those cases representing the more calamitous relapses. However, the anatomical peculiarities which produce a wider sutural opening anteriorly, emphasize the improvement in this area to the mutual gratification of both patient and clinician, and no case was entirely bereft of some satisfaction at the end of treatment.

Table I.—Maximal and Final Increases in Maxillary Width

Case	Initial Expansion	Final Expansion	Relapse (per cent)	Average Relapse (per cent)
1	4·5	2·25	50	
2	4·5	3·0	33	
3	5·25	3·25	38	
4	3·25	1·25	61	
5	5·0	2·75	45	
6	5·25	3·0	42	
7	5·25	4·0	24	
8	5·0	3·5	30	
9	4·75	1·75	62	41
10	5·25	2·75	48	
11	4·0	2·75	31	
12	5·25	3·5	33	
13	5·25	3·5	33	
14	4·75	3·25	32	
15	4·25	1·75	52	
16	4·75	3·5	26	
17	5·0	3·5	30	
18	3·75	1·5	60	
19	5·5	1·0	82	

N.B. Initial expansion is the increase in maxillary premolar width achieved by fixed appliance; measurements taken before fitting and immediately after removing splints. Final expansion is the difference in widths before treatment and at least 12 months out of retention.

DISCUSSION

The above data is in accord, where parallels exist, with previous work in this field, and confirms the technique's efficacy and conspicuous improvement over conventional expansion techniques. An analysis facilitates the formulation of an operative procedure germane to a successful therapeutic regimen.

The appliance need be no more bulky than some removables, neither should it be a source of discomfort. The programme follows orthodox principles and the patient is not restricted in his everyday life. In view of the frequent activations, this responsibility will lie with a parent or guardian who must be shown exactly what to do. To date, no failure has arisen from this quarter despite a few difficult starters, which is most gratifying, as parental co-operation was never a basis for selection. Normal attendances are once per week during the active expansion phase and once per month during the retention with the fixed splint.

It is impossible to be dogmatic on the best rate of expansion, there being a wide latitude between the minimal force capable of ensuring separation and the pain threshold.

If maximal sutural activity is to be procured, it is cogent to argue in favour of taking the expansion as fast as possible. Against this, we do not know what damage is being done and have only pain to guide us at the faster speeds. Present instructions are to turn the screw through 90° twice per day (night and morning). 90° of rotation is accomplished by two turns of 45° with long handled keys worked extra-orally. After the first week, with older patients, it is only necessary to turn the screw through 90° once per day to complete expansion.

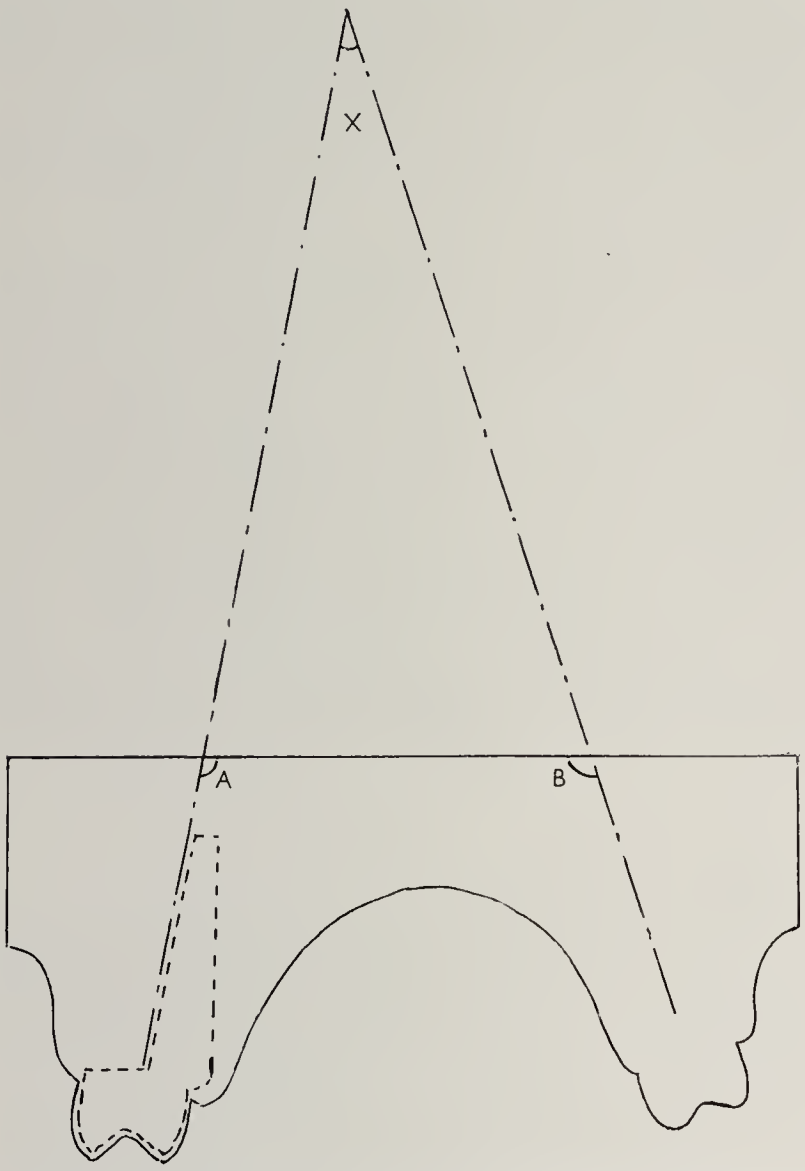

Fig. 4.—Transverse cross-section through maxillary model in molar region showing crown template in position to record tooth axis for angulation measurement. Angles A and B are measured and X calculated.

The expansion phase lasts 3–6 weeks depending upon the requirements and in this respect over-expansion by about one-third is necessary to allow for the partial relapse. After 3 months fixed retention, the splint is removed and replaced with a removable retention plate, which after 1 or 2 months is worn at night only. The overall period of retention is difficult to assess and reports in the literature vary between 3 months and 2 years. From personal experience a period of less than 12 months is courting relapse and one year from the removal of the splint would be a fair appraisal. Possibly there are individual factors operating, such as interdigitation.

There seems little reason for the stability shown in so many cases after this method of expansion other than a long period of retention.

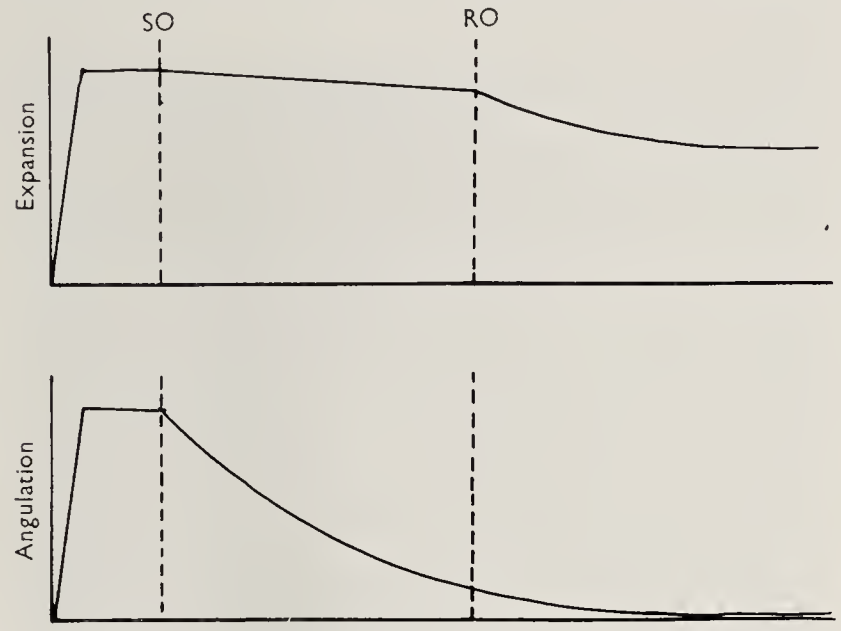

Fig. 5.—Graphs of synthesis of results by averaging. SO, point at which splints were removed. RO, point at which case came out of retention.

Table II.—Maximal and Final Angulation

Case	Maximal Angulation	Final Angulation
1	15	0
2	4	−2
3	12	+4
4	7	+3
5	2	−3
6	9	−3
7	9	−2
8	14	−4
9	9	0
10	6	−5
11	8	+6
12	13	+2
13	7	−2
14	10	+1
15	12	+1
16	12	0
17	13	+2
18	8	+1
19	11	0

N.B. Maximal angulation is the angular increase between the axes of the first standing molars, measured before fitting and immediately after removal of the splints. Final angulation is the difference between the angulation before treatment and that 12 or more months out of retention.

If the forces of relapse are imminent, no orthodontist would pin his faith on the rigidity of the newly formed palate, but he might argue better that the responsible musculature has been moved by its bony attachments.

If an ossified midpalatal suture is the only contra-indication to this technique, the bulk of the age-groups seeking orthodontic treatment will be covered and patient selection need not be particularly discriminating. The type of malocclusion eminently suited for this therapy is the complete lateral cross-bite starting at the midline.

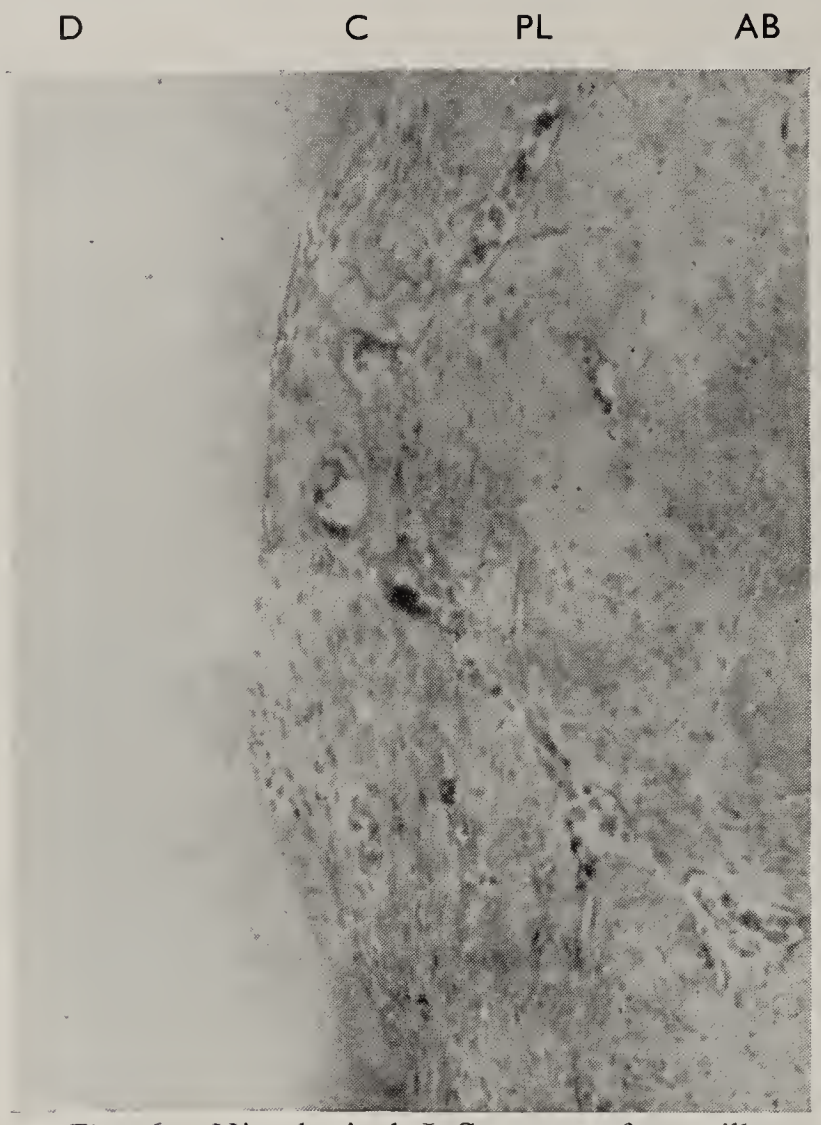

Fig. 6.—Histological L.S. root of maxillary molar on pressure side 4 months after expansion, showing loss of cementum and dentine but repair in progress. D, Dentine; C, Cementum; PL, Periodontal ligament; AB, Alveolar bone.

It is surprising what little extra dental space is acquired by quite wide expansions; crowding is not an initial requirement and extractions may still be called for in crowded maxillae. On the other hand, some anterior spacing may be increased by the expansion to the detriment of the cosmetics.

A caveat should be entered with respect to one undesirable sequel inseparable from this technique. The forces applied in this treatment are such that some damage is done to the roots (Rinderer, 1966).

From cases requiring maxillary extractions following expansions, 2 were selected for surgical removal of upper first molars together with a portion of the buccal alveolar plate. These teeth were subjected to histological examination and all showed areas of root decalcification, this being 4 months after active expansion. There were also signs of repair so perhaps this aspect need not be viewed too pessimistically (*Fig.* 6).

Apart from this inescapable denouement, very few contingencies need be expected; to date the author has recorded one quite massive epistaxis, a probable haematoma which resolved, and the worst episode was an acute ulcerative gingivitis which developed during the fixed retention phase and was treated with penicillin by another dentist. When again seen and the splint removed, a greyish slough detached itself, revealing an excessive loss of palatal gingival tissue.

The question is sometimes asked whether or not the suture suddenly opens when the force reaches some critical point. It has been mentioned that it is a simple and continuous withdrawal, the point of disjunction moving from anterior to posterior, but one case is of interest. A girl of 19 years was fitted with an appliance and instructed to turn the screw twice daily. On the third day she contacted the hospital, saying she had a sudden painful sensation as though punched on the nose, her eyes lachrymosed and a glance in the mirror revealed a superior median diastema which hitherto had been non-existent. These symptoms point suspiciously to an instant sundering of the midpalatal suture but it should be noted that no other patient has reported a similar consequence.

CONCLUSION

From this unsophisticated investigation, based on the records immediately to the orthodontist's hand, namely his study models, lateral maxillary expansion with midpalatal suture opening is a valid and worthwhile orthodontic procedure providing these points are observed:—

1. Use a fixed appliance and control expansion with a screw.
2. Expand rapidly to ensure sutural changes, and approximately one-third more than required.
3. Maintain in retention for at least 12 months, 3 of which should be with the fixed appliance.

If originality is the salt to a scientific treatise, this work has lost its savour in the passing of the last hundred years, but purpose has been served if interest is rekindled in this very useful technique and its application is furthered.

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DISCUSSION

Mr. J. P. Moss opening the discussion said that, as Mr. Timms knew, in the cases he treated by rapid expansion he used a different appliance from that used by Mr. Timms. Cap splints covering the teeth and a rigid screw across the centre of the palate, attached to the two splints, were used. Looking at the results, it seemed alarming that there was such a high percentage of relapse. He had not experienced quite the same amount of relapse and wondered whether Mr. Timms would like to comment on whether perhaps, since the screw he used was free, the two splints allowed the teeth to tilt outwards.

So far as retention was concerned, he entirely agreed with Mr. Timms that a year was the minimum time for retention in these cases. He had had exactly the same experience as Mr. Timms in patients who left out the appliance—the expansion almost completely relapsed.

He also wished to ask Mr. Timms regarding the angular measurements he had made. Had he used the same template for each of his models? If he did, since this would not fit on each of the teeth, did he fit it on the buccal or lingual surfaces of the teeth? How accurate did he think his measurements were?

Mr. Timms had not mentioned anything about the indications for the treatment by rapid expansion. He noticed that in nearly all Mr. Timms's cases, the expansion was in the region of 3–5 mm. which seemed quite small.

He would like to know what age Mr. Timms thought was ideal for treatment.

He would also like to know why this type of expansion did not relapse completely. Normal expansion with the usual type of expansion appliance, seemed to relapse completely, but with this type of expansion there was not the same amount of relapse.

Mr. Timms referred first to the problem of relapse and said that it was quite unavoidable because of the uprighting of the teeth later, but preparation was made for this by excessive initial expansion. His 41 per cent had apparently caused some disturbance and he put that down to a few bad cases.

As regards the screw, the early cases had been done with the Glenross screw. That was why there was a maximum of $5\frac{1}{2}$ mm.

He had selected the cases solely on the malocclusion and he had even expanded cases with poor teeth to improve the buccal base relationship where he felt there would be an advantage. He found that the ideal was probably to do it when the premolars had erupted, at about 12 years. He had done it in the deciduous dentition but preferred the permanent dentition. Two of his oldest patients were 19 years.

He knew that people did them a little older. In fact, he thought Mr. Moss knew of a case treated at the age of 31, and Dr. Derichsweiler had a case at the age of 39 but would have thought that there would be some ossification of the midline suture at that age.

Mr. J. R. Pettman suggested to Mr. Timms that possibly these conditions did not relapse for similar reasons that a fracture did not relapse completely, and that the tissues perhaps healed in a new position, just as they healed after a fracture.

An interesting thing he noticed was that there was a considerable change in the external shape of the nose and the patient should be warned about this.

He found a rather disturbing thing that happened was that sometimes one lateral segment went off sideways and apparently dislocated, while the other buccal segment stayed more or less where it was, so that in a short time one group of molar teeth on one side had corrected the cross-bite and perhaps tilted a little, whereas because the sutures on the other side of the face had not given, that did not move so much.

Mr. Timms said, on the first point, that he did not think this was quite the same as a fracture. It was not only the suture that changed. One had still got to cope with the musculature.

With regard to the nose, there was not very much change, and though there might be about 10 mm. expansion of the teeth, only about 3–4 mm. seemed to occur at the base of the nose. It was surprising how the expansion effect tapered off.

He had the impression that some of his cases probably moved more one side than the other, but it was not sufficient to upset the technique as a means of correcting the cross-bite relationship.

Mr. F. Allan did not follow Mr. Timms's explanation of how his appliance worked. The fact that the screw worked at root level did not mean that the teeth would move bodily. As soon as the screw was turned once or twice, the whole appliance would hit the soft tissue and lift itself out of the palate. The teeth would then tilt, as they were cemented to the appliance.

Mr. Timms said that, taking one maxillary segment, you had the teeth with a cap splint on them and there was a palatal extension. The teeth were moving together with the maxillary bone and the soft tissue.

Mr. C. D. Parker asked whether a mandibular displacement had been detected in any of the cases before treatment by rapid expansion. Once appliances were discarded, did the degree of relapse cause in certain cases, the establishment of a mandibular displacement? If this was so, did this require further appliance therapy or did it respond to simple grinding of the teeth?

Mr. Timms said that he had not followed any mandibular displacements in this treatment. He based the treatment solely on the occlusal relationship.

Mr. W. A. B. Brown said that Mr. Timms had replied to a question, that the teeth were not tilted and moved bodily and yet he had measured a change of angulation of the teeth from the study models with the aid of a template. What then did this angle measure?

Mr. Timms said that the teeth with their respective maxillae were moving as a single unit but hinging about a point in the ethmoid region. They were not moving in a straight line.

Mr. A. G. T. Allcorn asked Mr. Timms whether, if relapse occurred in the first twelve months, he would expect further relapse to occur in the subsequent years.

Mr. Timms said that four sets of study models was the minimum for the course. Ideally one required two final study models taken some months apart, registering no changes, to show that stability had been reached. This had been done in a few cases.

THE PROBLEMS OF DENTAL DEVELOPMENT AMONG THE CHILDREN ON A GREEK ISLAND

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MANY surveys of the prevalence and nature of malocclusion have been undertaken since Angle (1899) published his survey of 1000 cases (Korkhaus, 1928; Sclare, 1945; Humphreys and Leighton, 1950; Massler and Frankel, 1951; Gardiner, 1956; Heffer and Lovius, 1963; Walther, 1960). An invitation from the North Euboean Foundation, a benevolent advisory trust, to investigate the dental health of an economically poor community on the Greek island of Euboea was received by those of us treating children at University College Hospital. This community was of particular interest for three main reasons. Firstly, the community as a whole has been relatively isolated, access to the area being restricted geographically and economically. Although great strides are now being made to make the area accessible by road, some of the villages could only be reached by sea or by a 3-hour mule trek. One of the results of this isolation is that there is considerable intermarriage in the area. The second important factor influencing this community is the almost complete lack of dentistry amongst the children. Dentistry is restricted, except for a few extractions, to adults, only 3 fillings, 2 of them temporary, were seen in the children in this survey. In this group of children could be seen the effect of malocclusion on the dental arches without the superimposed effects of modern dentistry. The third reason was that we had been told by the Advisor of the North Euboean Foundation that the children suffered from poor teeth and that the traditional method of breast-feeding was being replaced by bottle feeding with sweetened condensed milk.

There were three main objectives of the survey. Firstly to determine the oral health of the childre and, secondly, to offer help and guidance to overcome their dental problems. Finally we wished to know the effectiveness of the measures recommended. This communication deals with the limited orthodontic examination which was undertaken during the survey.

GEOGRAPHY

Euboea is a large Greek island, 110 miles long, lying off the coast of the Greek mainland on the Aegean side. The region influenced by the Foundation is near the centre extending to the coast on each side and bordered by low mountains to the north-west and south-east. The region has a central plain surrounded by hills. The lowlands are extensively cultivated in small-holdings, each family growing its own food supply. The hills are covered with pine forests and the Alleppo pines are tapped for resin which is collected and used for the production of turpentine. Recently the open-cast mining of magnesite has brought increased prosperity to the area.

MATERIAL

Five hundred and fifty-three children under the age of 12 years, from 28 different villages were examined. These villages varied in their location, mountain, hill, or plain, and in their accessibility to the main road, being classed as remote or accessible.

METHOD

To obtain the first objective, 28 villages in the area were visited and approximately 20 children

Presented at the Jubilee Meeting held on 9 May, 1968.

under 12 years of age from each village were examined. The local Greek-speaking English paediatrician, Dr. Blackburn, accompanied us on each journey acting as our interpreter. She also took an extensive history of each child including the data on the family and the diet. At the same time information on each village

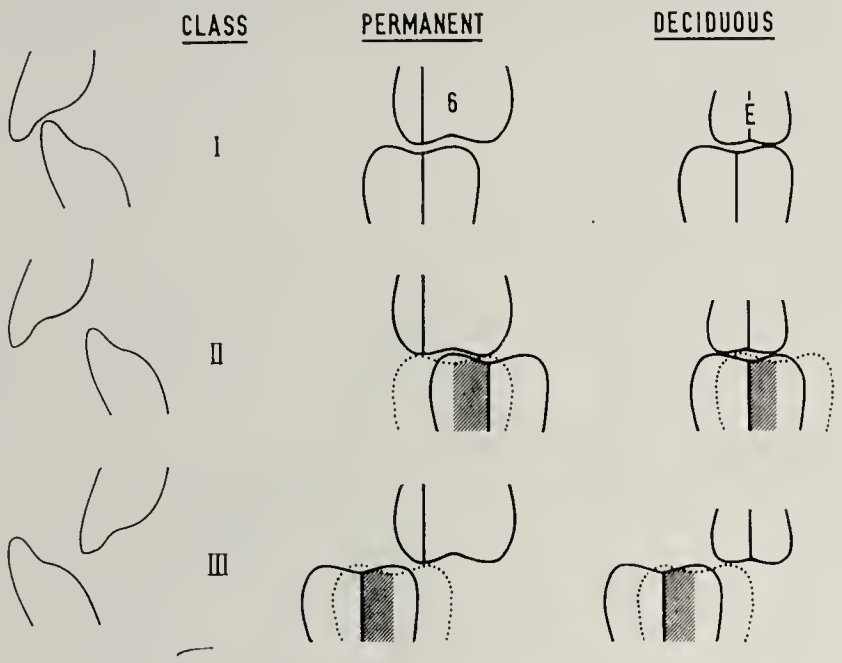

Fig. 1.—This diagram shows the position of the molar teeth used in the classification of the children in this survey. The shaded area shows the position of the molars in cases which were classified as ' tendencies '.

was obtained, such as the number of water taps, the economic status, the presence of a school. Samples of the various sources of water were taken and tested for fluoride content using the technique described by Palin (1963).

Each child was examined in turn with a mirror and probe and the orthodontic examination was undertaken at the same time. Each mouth was charted for caries and the location and severity noted of gingivitis, debris, and calculus. As electricity was unobtainable in many villages, sunlight was used for illumination wherever possible.

The orthodontic examination was limited due to the facilities and time available, especially as many of the villages were inaccessible and often took several hours to reach. Each child was assessed using Angle's classification of the molar teeth, correcting the molar relationship where necessary. If no molars were present the position of the canines was used. The children who were full unit pre- or post-normal were recorded and also those who were between one-half and one full unit pre- or post-normal (*Fig.* 1). These latter cases were termed ' tendencies '. The degree of overbite was classified as being normal when the upper incisor covered the incisal third of the lower incisor and decreased when it was less than one-third and increased when two-thirds or more were covered. Open bites and incomplete overbites were also recorded. The overjet was classified as increased, normal, edge-to-edge, or reverse. Crowding of the teeth was assessed subjectively and the drifting of deciduous teeth assessed similarly or if necessary using a pair of dividers. The closing movements of the mandible were assessed visually and also by palpation of the temporal and masseter muscles bilaterally.

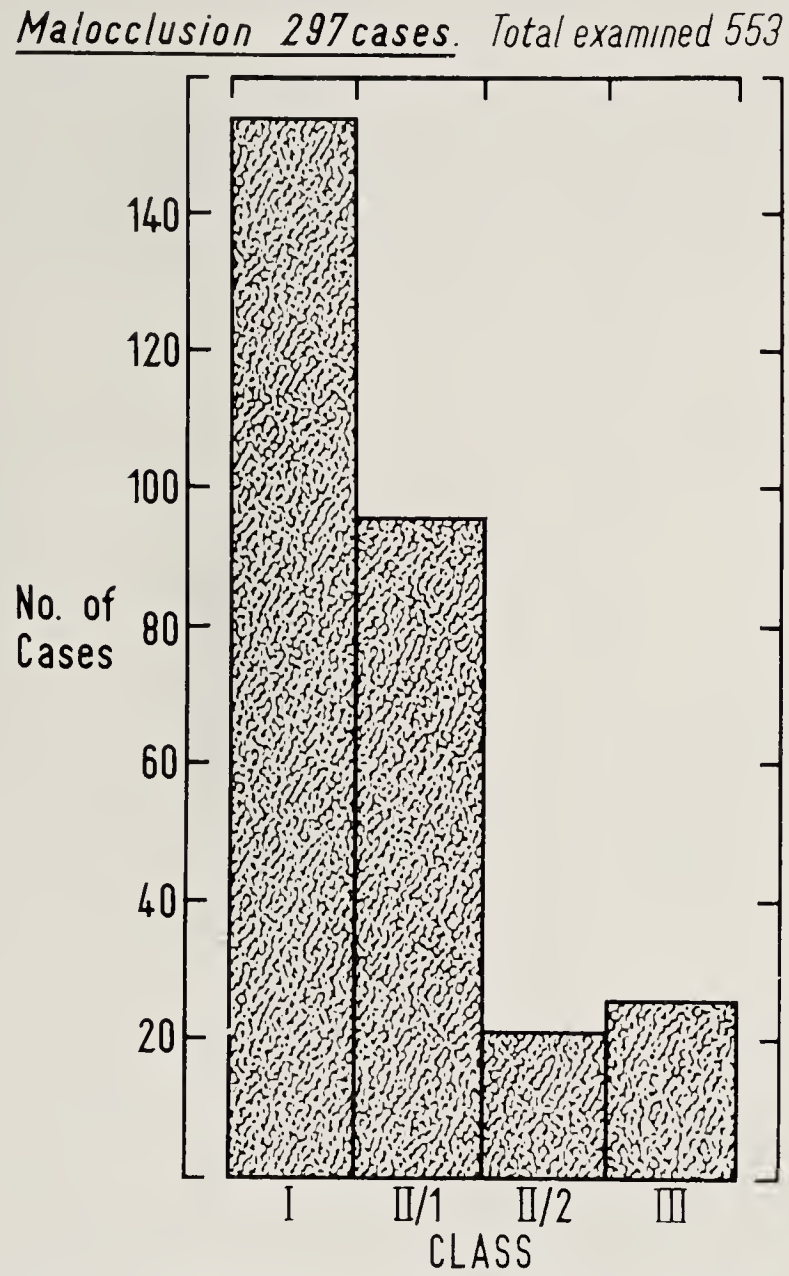

Fig. 2.—Histogram of the prevalence of malocclusion in the group of children examined.

The lip morphology was assessed with the patient in an upright position and the children were divided into three groups; firstly, the lips were assessed as competent when the lips met together at rest; secondly, as incompetent when they failed to meet at rest; or thirdly, as potentially competent when it seemed possible that they would have met together at rest if the dental obstruction were removed.

RESULTS

Age Distribution of the Prevalence of Malocclusion

Five hundred and fifty-three children were examined and 297 had a malocclusion (54 per cent). The prevalence of malocclusion in this group of children was similar to the incidence of malocclusion found by other workers (Korkhaus,

1928; Sclare, 1945). Twenty-seven per cent of the cases examined had a Class I malocclusion, 17 per cent had a Class II, division 1 malocclusion, 4 per cent had a Class II, division 2 malocclusion and 5 per cent had a Class III malocclusion (*Fig.* 2). A graph of the prevalence of malocclusion in the whole group was plotted and it was noted that the total prevalence of malocclusion decreased to the age of 6 years and then increased rapidly to a level of approximately 60 per cent at 7 years. It was noted that the over-all dates of eruption of teeth were slightly retarded in this group of children, compared with dates of eruption in the United Kingdom. *Fig.* 3 illustrates the prevalence of malocclusion of each type at the various ages. It will then be seen that the prevalence of the Class II, division 2 and Class III malocclusions was low, and that up to the age of 5–6 years the incidence of Class I malocclusions remained fairly constant. However, the incidence of normality increased up to the age of 5–6 years, and this increase was a mirror image of the decrease in Class II, division 1 type of malocclusion. The incidence of Class II, division 1 malocclusion in this group of children decreased to the age of 5–6 years.

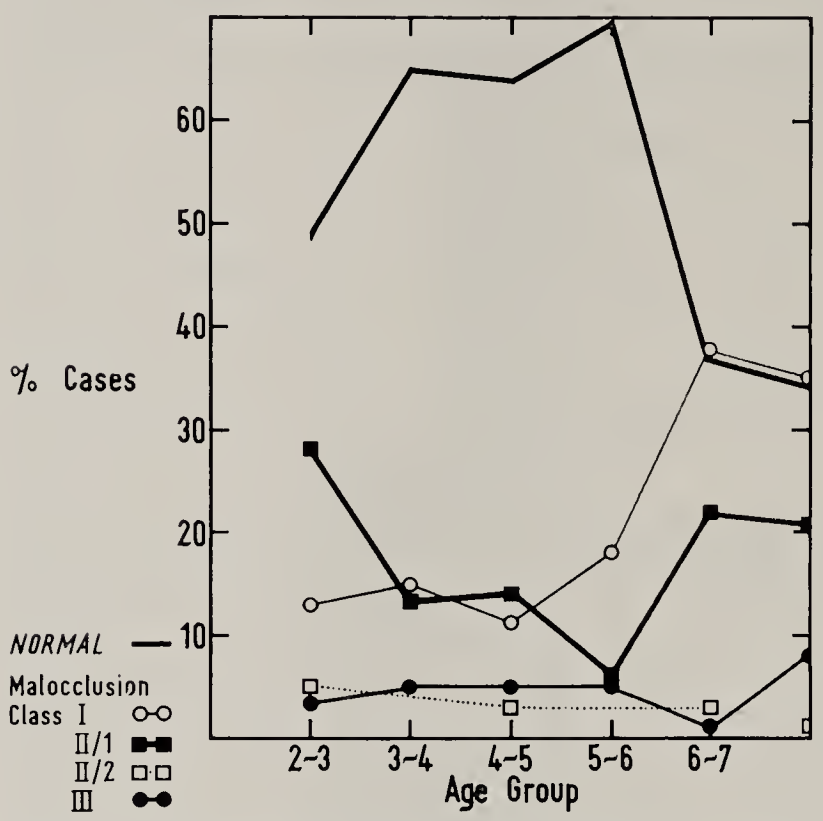

Fig. 3.—A graph to show the prevalence of the types of malocclusion up to 6 years.

During the next year the incidence of malocclusion increased in the Class I and Class II, division 1 groups and, therefore, the percentage of normality decreased (*Fig.* 4). There was a further sharp decrease in the incidence of normality at 8–9 years and a corresponding increase in the incidence of Class I malocclusion. This was due to the later eruption of teeth in the population as a whole and, therefore, erupting incisor teeth which were not in occlusion were registered as an incomplete overbite. Excluding the increase in Class I malocclusion for this cause the curve follows an expected pattern and it will be seen that the incidence of the various types of malocclusion remains fairly constant up to the age of 12 years.

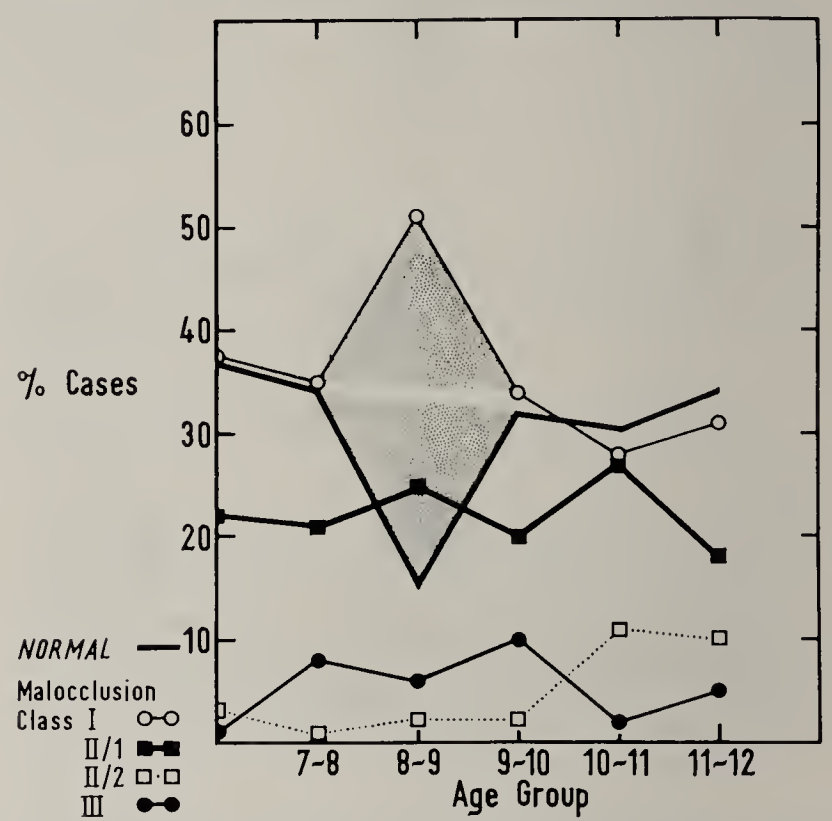

Fig. 4.—A graph to show the prevalence of the types of malocclusion at 7–12 years. The shaded area indicates the number of cases which were classified as Class I malocclusion due to the presence of an incomplete overbite at the time of the eruption of incisor teeth.

Method of Feeding and Malocclusion

The breast-feeding of infants is still traditional in this part of the country, 57·7 per cent being breast-fed for at least 1 year and 7·2 per cent for more than 2 years. The traditional method of breast feeding is being replaced by feeding with condensed sweetened milk and, therefore, it gave us an opportunity to assess the affect of breast-feeding on the dental arches and to compare these results with children who were bottle-fed for a similar period of time.

Many dental abnormalities have been attributed to bottle-feeding as opposed to breast-feeding, largely because of the difference in the mechanical effect and not because of different characteristics of the milk.

It was noted that the incidence of Class II, division 1 malocclusions in the whole group seemed higher in children who had been breast-fed than in bottle-fed children. However, this difference was not statistically significant. If breast-feeding does influence the dental arches the effect would be most noticeable during the deciduous dentition. There were 79 children of 2–6 years of age who had been breast-fed for more than 12 months and 49 children of the same age who had been bottle-fed for a similar length of time.

Fifteen of the breast-fed group had a Class II, division 1 malocclusion whereas only 2 of the bottle-fed group were in this category. There was statistically significantly more Class II, division 1 malocclusion in the breast-fed group, using chi-square $P<0{\cdot}02$ (*Table I*). There was no difference between boys or girls.

The incidence of caries (def-teeth) in the 2 groups was statistically significantly greater in bottle-fed children ($P<0{\cdot}02$) for the range 2–4 years. After this age there was a very rapid increase in caries in the breast-fed group and within 1 year the incidence of caries was as high as in the bottle-fed group (*Fig.* 5). The general prevalence of caries was higher than that for the United Kingdom Fluoridation Study (1962) (*Fig.* 6).

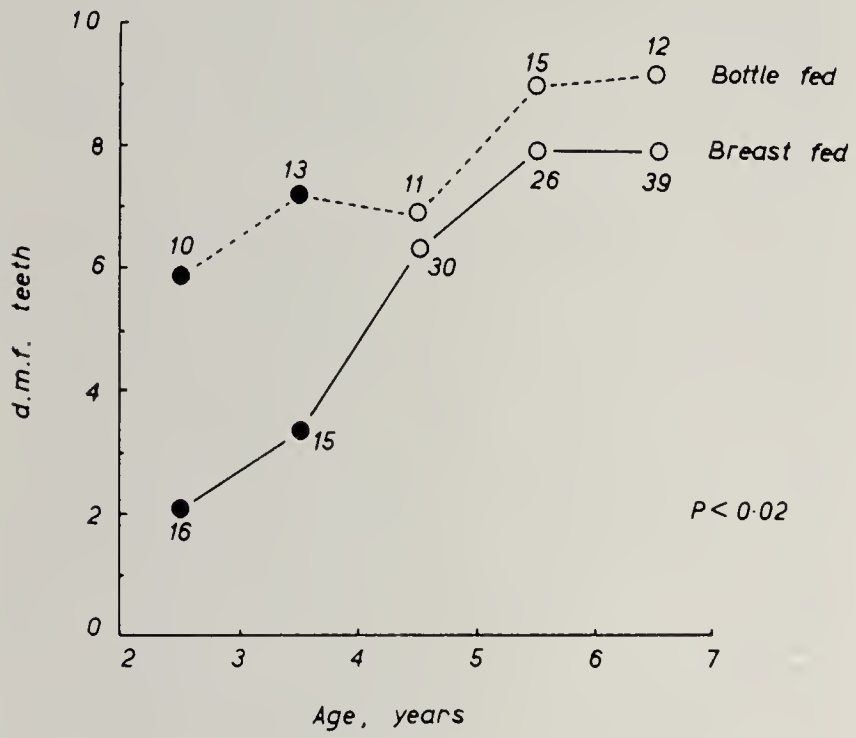

Fig. 5.—The prevalence of caries in children breast-fed for more than 12 months compared with children who had been bottle-fed.

Table I.—The Incidence of Class II, Division I Malocclusion in Children aged 2–6 Years

	Class II, Division I Cases	Total Cases
Breast-fed children	15	79
Bottle-fed children	2	49
Significance	$P<0{\cdot}02$	

The numbers of breast- and bottle-fed children with a Class II, division 1 malocclusion are shown. The difference was statistically significant.

It has been suggested that bottle-feeding is associated with narrow and crowded arches, so a comparison of the presence of crowding or spacing was undertaken; 12·5 per cent of the bottle-fed children had crowded arches and 12·8 per cent of the breast-fed children had crowding.

Many abnormal swallows and open bites have also been attributed to bottle-feeding but no difference could be established between these two groups in view of the limited nature of the examination.

Habits

There was a very low incidence of sucking habits in this group of children, only 10 had a history of thumb sucking and only 1 of these showed any malocclusion; 15 sucked other things such as hand, tongue, clothes, etc. The incidence of sucking habits was less than 5 per cent which is low compared with other surveys.

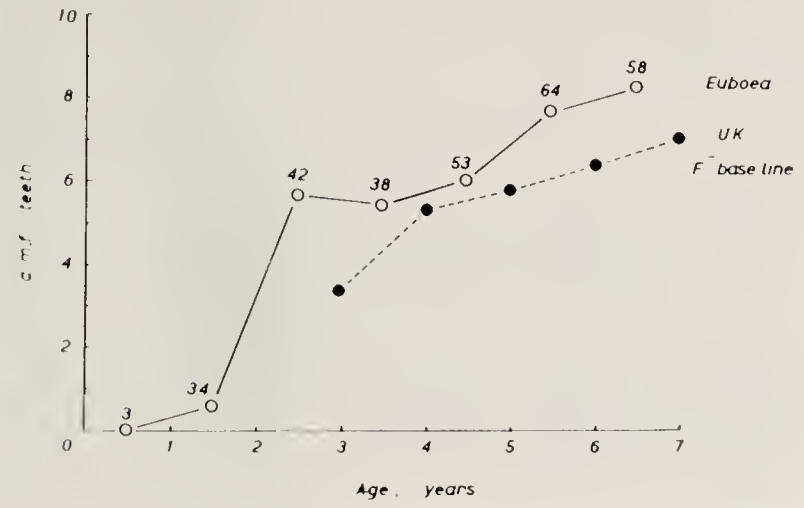

Fig. 6.—The prevalence of caries in children of Euboea compared with the United Kingdom Fluoridation base line.

Loss of Deciduous Teeth

Loss of space due to early extraction of deciduous teeth was only found in 10 cases, 1·8 per cent. This was observed clinically and where necessary dividers were used to assess space loss.

Fractured Teeth

There were 9 cases of fractured incisors, 5 in the deciduous dentition, and no dislocations.

Mandibular Displacement

Deviation of the jaws occurred in 10 per cent of children in this survey. Thirty-eight deviated to the right and 17 to the left. There was also 1 anterior displacement and 1 posterior displacement. The percentage of displacements increased slightly in the mixed dentition.

Lip Morphology

Eighty-three per cent had a competent lip morphology and when the incidence was plotted for each age-group it was noted (*Fig.* 7) that up to the age of 5–6 years the incidence of incompetent lips was low. However, with the eruption of the permanent incisors, lip incompetence increased and then there was a gradual decrease.

Abnormalities

One cleft palate was seen and there was a strong hereditary tendency in this case. The cleft palate was repaired in a nearby hospital in the largest town on the island.

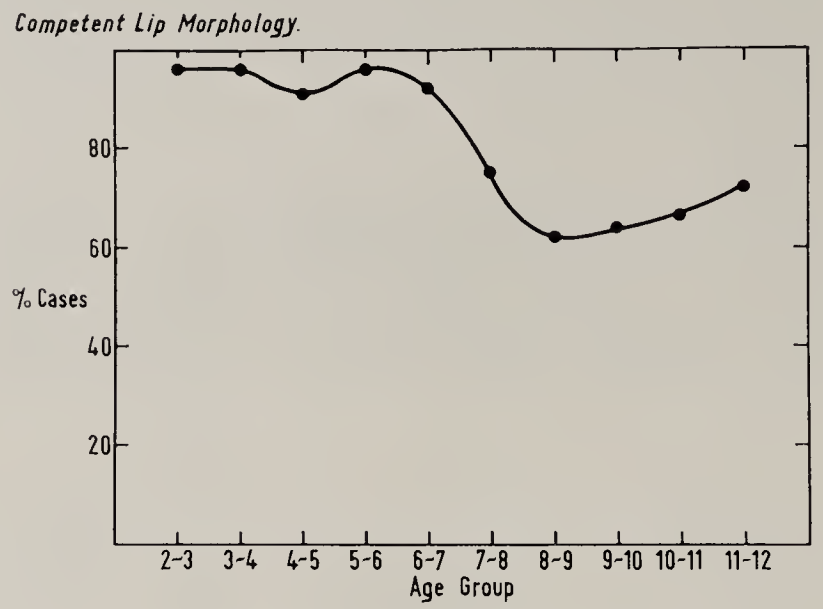

Fig. 7.—The prevalence of competent lip morphology at the ages of 2–12 years.

The incidence of other dental abnormalities seemed low, only 3 cases of supernumerary teeth, 4 cases of partial anodontia, and 1 case of submerged teeth being seen.

DISCUSSION

Angle's method of classification has been used in most surveys since he published his survey in 1899. Since that time numerous people have reported the incidence of malocclusion in various age-groups (Korkhaus, 1928; Sclare, 1945; Humphreys and Leighton, 1950; Massler and Frankel, 1951; Gardiner, 1956; Walther, 1960). The prevalence of malocclusion, 54 per cent found in the present group of children, is similar to the prevalence reported by Korkhaus (1928) in his survey of 6–14-year-old children but was lower than that found by Massler and Frankel (1951). However, a direct comparison with other surveys is difficult as the age range and criteria used are not exactly comparable.

The lower incidence of malocclusion found in the present group might have been due to the fluoride content of the water. Thus it has been suggested that there is a relationship between the prevalence of malocclusion and the concentration of fluoride in the water (Ast, Allaway, and Draker, 1962; Tank and Storvick, 1965). If the fluoride content of the water had been high it could give a reduction in dental caries and a decreased incidence of malocclusion. However, the fluoride content of the water tested was in the order of 0·4 p.p.m. or less in all the villages visited. The def-teeth was slightly higher than in a comparable age-group in this country so that this level of fluoride seems unlikely to have influenced the prevalence of malocclusion. The virtual absence of extraction of grossly carious teeth could have had a minor effect, however.

Very few orthodontic surveys of young children have been undertaken (Northcroft, 1910; Humphreys and Leighton, 1950). The latter reported an incidence of 25 per cent post-normality and 1·5 per cent pre-normality in children under 5 years in Birmingham. In the present survey the incidence was 19 per cent post-normality and 5 per cent pre-normality. Humphreys and Leighton also noted that boys had a 3·8 per cent greater incidence of post-normality, and this was significant but in this group of Greek children the incidence of post-normality was equal, 19 per cent.

During the period of 2–5 years the prevalence of post-normality decreased and the prevalence of normality increased, suggesting that post-normality improved as the children became older. This was contrary to the findings of Humphreys and Leighton who found no decrease in post-normality between the ages of 2 and 5 years. The prevalence of the various types of malocclusion remained fairly constant in the 6–12-year-old Greek children. In the deciduous dentition there was a spontaneous improvement in the prevalence of post-normality, but once the permanent teeth had erupted there seemed to be little improvement, in fact, there was probably a slight tendency for the prevalence of post-normality to increase.

The effect of breast-feeding on the dental arches has been discussed by Humphreys and Leighton (1950). They found that post-normality was more frequently associated with bottle-feeding but no statistical significance was found. In this present survey the prevalence of post-normality in breast-fed children was greater than in bottle-fed children in the deciduous dentition and this was statistically significant ($P<0{\cdot}02$). In discussing the biological significance of this finding, one must remember that although statistical analysis may show a close relationship it is not necessarily a causal relationship (Scherp, 1964). One of the differences between bottle- and breast-feeding, assuming the population to be homogeneous, is the degree of muscular effort and pressures exerted in sucking and swallowing. During sucking the jaw is raised and the lower lip contracts against the breast, whereas in bottle-feeding the milk is deposited on the surface of the tongue. The development of the normal swallow must have been delayed as many of these children would have had deciduous teeth present whilst they were still being breast-fed, so that the teeth would not have occluded during feeding and the pressures from the lips and the negative pressures in the mouth may have caused excessive pressure on the lower jaw for a considerable period of time. The continuance of breast-feeding may have delayed the spontaneous improvement seen generally in the group, and

hence in the older group from 6 years of age there was no statistical significance in the prevalence of post-normality between breast- and bottle-fed children.

Breast-feeding conveyed a protecting effect on the teeth up to the age of 4 years. After this age the incidence of caries increased and within a year the experience of caries was as high as in the bottle-fed children. The importance of these findings has been discussed elsewhere (Picton and Moss, 1968). The children in the area have little or no dental treatment, only 1 permanent filling and 2 temporary fillings were seen in over 550 children examined. The course of dental caries was, therefore, a steady progress to abscess formation, resulting in a sinus and exfoliation of the roots of the teeth. There was little difference in crowding whether a child was breast- or bottle-fed, 12·5 per cent or 12·9 per cent respectively, suggesting that the method of feeding had no effect on the crowding of the dental arches.

It is interesting that only 1·8 per cent of the children had loss of space due to the early loss of deciduous teeth. This is very low compared with the incidence of space loss found by Gardiner (1956) of 19 per cent in a group of Sheffield schoolchildren. The difference may be due to the fact that most of the teeth in our survey were not extracted but were left to exfoliate. The incidence of crowding due to an adverse tooth: tissue ratio was 24 per cent and this was high compared with 11 per cent recorded by Gardiner (1956). As this was assessed clinically it is impossible to compare the results directly.

The incidence of sucking habits was very low, less than 5 per cent, whereas the incidence in other surveys was high: 32 per cent, Hanna (1967); 27 per cent, Gardiner (1956); 39 per cent, Bowden (1966). Of the 25 children with a history of a sucking habit only 4 had a malocclusion. Various suggestions have been made as to the reason for thumb-sucking. Thus Bowden (1966) suggests three: firstly, the reflex sucking of digits due to the foetal position, as discussed by Coghill (1929) and Hooker (1942); secondly, a frustration of the oral drive to suck; and lastly psychological stress. Another suggestion by Davidson, Haryett, Sandilands, and Hansen (1967) is that it is a learned habit. Most of the children in this survey were either breast- or bottle-fed for over 9 months so there was little frustration of the oral drive to suck. The paediatrician who had worked in the area suggested that the incidence of sucking habits was least in the villages where the babies were swaddled. This custom, although discouraged by certain midwives, is still practised, as is the custom of swaddling the child for three days in a cloth soaked in the local wine, Retzina. There seemed to be a greater incidence of sucking habits in the accessible villages and nearly all cases were found in four villages which suggest that in these villages there may have been more psychological stress, or that the children learned it from one another. The children generally were extremely happy and co-operative. In fact, in some villages we were beset by mothers insisting that we examined their children—perhaps they were thinking of Socrates when he said ' the unexamined life is not worth living '.

Another surprising finding was the low prevalence, 1·6 per cent, of fractured incisors, especially considering the rocky terrain and the liability to damage. Ellis (1960) quotes a prevalence of 4·2 per cent in American children and Grundy (1959) puts it as high as 6 per cent in English children. Grundy attributes most of these fractures to falls: it may be that, due to the rocky terrain and the lack of municipal swings and pavements, the children in this area are more sure-footed and, therefore, less liable to trauma of this type.

Of the 57 children who had a deviation of the jaw, 15 cases were associated with crowding of the teeth and 11 cases were with a pre- or post-normality. The prevalence of mandibular displacement increased in the mixed dentition after the age of 7 years. There was a decrease between the ages of 7 and 9 years which was during the period of incisor eruption, indicating that the increase after the age of 9 years was probably due to the eruption of the permanent teeth.

The prevalence of incompetent lips seemed to increase after the age of 5–6 years suggesting that the growth of the lips did not keep up with the general growth of the alveolus as the teeth erupted. Heffer and Lovius (1963) also noted in their survey of the islanders of Tristan da Cunha that the incidence of incompetent lips was greatest in the groups aged 6–11 and decreased gradually as the age increased.

SUMMARY

1. Five hundred and fifty-three children from 28 different villages of the Greek island of Euboea were examined.

2. The prevalence of malocclusion was similar to that found in surveys undertaken in Britain and on the continent.

3. The incidence of post-normality decreased between the ages of 1 and 6 years and the incidence of normality rose.

4. There were significantly more cases of post-normality in breast-fed children under the age of 6 years than in bottle-fed babies ($P<0·02$).

5. Compared with other surveys there was a lower prevalence of sucking habits, fractured incisors, and dental abnormalities.

Acknowledgements

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RESEARCH REPORTS

VITAL TRANSPLANTATION OF TEETH. By B. B. J. Lovius, F.D.S., D.Orth. R.C.S., and D. G. Huggins, F.D.S., D.Orth. R.C.S., Liverpool Dental Hospital.

The misplaced maxillary canine tooth presents a problem whose gravity depends on:—

1. The amount of space or crowding present.
2. The position of the tooth.

In patients with a good upper lateral incisor/first premolar contact, the loss of the canine will in most cases be the treatment of choice, but in those with some space available, it is usually preferable to move the canine into alinement using conventional orthodontic means. However, there is a proportion of patients who have both ample space for the canine (perhaps abetted by some prior orthodontic treatment) together with a misplaced canine which is unable to be repositioned orthodontically. In these cases, surgical transplantation should be considered.

In Liverpool and Chester approximately 30 teeth have been transplanted during the last 18 months. The early ones were root-filled at the time of operation, but because of progressive root resorption, such as observed by Heslop (1967), all the latter ones have been vital transplants, following the technique of Thonner (1967).

The technique used is surgical removal of the canine with minimal trauma, followed by storing the tooth in serum (obtained from the patient after antibiotics have been given) at 37° C., whilst the socket for the canine is prepared. The transplanted tooth is then splinted into position for 3–5 weeks.

Following removal of the splint the tooth appears slightly more mobile but 2 months postoperatively the mobility of the transplanted tooth is normal.

Recent work in America (Fong, Morris, and Grant, 1967) on experimental tooth transplantation in the Rhesus monkey suggests initial pulpal necrosis followed by connective tissue replacement, which by 3 months has the appearance of normal pulp tissue. We hope that we are obtaining a similar response in our patients but this is as yet a preliminary report and we hope to be able to report again on our long term follow-ups.

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STUDIES IN THE FORM AND DIMENSIONS OF THE PRE-DECIDUOUS MAXILLARY ARCH IN UNILATERAL CLEFT LIP AND PALATE CASES. By A. G. Huddart, B.D.S., F.D.S., D.Orth., Consultant Orthodontist, Birmingham Regional Plastic Unit

This is a progress report on the cleft palate research programme originally outlined to the 1963 research session of the B.S.S.O.

So far, attention has been concentrated on studying the changes in the size and shape of the predeciduous maxillary arch in unilateral cleft lip and cleft palate cases following presurgical dental orthopaedic treatment.

In order to facilitate measurements of the plaster record models, photostat reproductions of them were made in both the horizontal and transverse planes using a Rank Xerox 914 photocopying machine.

A preliminary study of the effects of presurgical treatment on unilateral cleft lip and palate cases has shown, amongst other things, no evidence of tissue growth being stimulated by the appliances. The main effect of treatment has been to minimize the increase in width of the upper arch which should normally take place as craniofacial growth proceeds. In consequence the growth taking place at the cleft margins has been available to narrow the width of the palatal defect.

It is intended to repeat this work in greater detail in the near future, particularly to obtain more information about the responses of individual cases to presurgical treatment.

A further study has also just been completed comparing thirty unilateral cleft lip and palate cases with thirty normal cases at birth and it is hoped to publish this in due course.

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A METHOD OF DEMONSTRATING CHANGES PRODUCED BY PRESURGICAL ORAL ORTHOPAEDICS. By N. R. E. Robertson, M.D.S., F.D.S., D.D.O., and R. Hilton, L.D.S., D.D.O., Turner Dental School, University of Manchester and the Royal Manchester Children's Hospital

Introduction

Presurgical oral orthopaedic treatment for newborn infants has been employed in many centres since first described by McNeil in 1950. In some instances, the changes which it produces can be seen with the naked eye, but both here and in cases where the changes are less obvious, their nature is not entirely understood.

For example in bilateral complete clefts—is the premaxillary segment moved backwards or restrained? And in unilateral complete clefts—are the segments rotated about axes or does treatment produce collapse of one or both segments?

Techniques

In trying to answer questions such as these a method of demonstrating changes was sought. A fixed landmark in each of the jaw segments was required and Björk's (1951, 1955) method of inserting tantalum implants was used. Implants were placed

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in each of the upper jaw segments and also in the lower jaw in sedated infants. Pre-treatment frontal and lateral cephalograms were obtained in the Wehmer cephalometer and repeated after 12 weeks' treatment. The number of infants examined in this study is 25.

Cephalometric Analyses

1. *Lateral Headplates*

The distance between ' S ' and the most posterior part of each implant was measured on the pre- and post-treatment tracings with dividers.

2. *Frontal Headplates*

The ' X ' line described by Harvold (1954) was taken to represent the midsagittal plane of the head and measurements made from ' X ' line to the nearest point of the implants on pre- and post-treatment tracings.

Measurements were also made between corresponding implants on each side.

Findings

1. *Bilateral Clefts*

The principal changes are restraint of forward growth of the premaxilla rather than distal movement and forward movement of the maxillary segments. There is no appreciable collapse of the segments.

2. *Unilateral Clefts*

Here the changes appear to be rotational, about axes in the retromolar area. The minor segment is seen to move forwards. Again there is no appreciable collapse of the segments.

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CLASS III OCCLUSIONS IN PATIENTS WITH CLEFTS OF LIP AND PALATE

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INTRODUCTION

THERE have been several investigations into the skeletal and occlusal differences between cleft and non-cleft patients. Most of these have not differentiated between the types of clefts, and the control cases have usually been normal or a cross-section of non-cleft cases with assorted malocclusions. There has been a considerable number of variable factors, and very little in common between the groups compared. Thus any direct associations between specific abnormalities and specific clefts have been very difficult to determine.

In 1962 I published a paper in which I described the clinical appearances of malocclusions associated with different types of clefts. From this work I felt it would be interesting to investigate more fully. In 1966 I published a further paper with some results of a comparison of 387 cleft cases and 100 non-cleft cases with assorted malocclusions. The 387 cleft cases were divided into groups according to cleft type and this division produced 13 groups. Some of these groups were very small and the malocclusions varied considerably. Similarly, the control group had a wide variation in malocclusions.

Therefore, it was felt that it would be interesting to select those cleft cases of a certain type of malocclusion and compare them with non-cleft cases of the same type of malocclusion. In this way, any variations in the cleft cases from the non-cleft cases of otherwise similar types would be more likely to be due to the cleft. It was decided to concentrate first on the Class III or prenormal malocclusions as these are the most difficult to treat in cleft cases.

The 387 cleft cases mentioned above were from the Hospital for Sick Children, Great Ormond Street, and I was given permission to continue the study of these cases. Of these 387, 195 were found to have Class III malocclusions. Of these 195, 122 had unilateral complete cleft of palate and cleft lip, 57 had bilateral complete cleft of palate and bilateral cleft lip, 9 had cleft palate only, 3 had cleft lip only, and 4 had clefts of lip and palate not-united. These last three groups were considered too small to be of any great value and were discarded. Of the 122 cases with unilateral cleft palate with cleft lip, 3 were rather unusual in that they had bilateral cleft lips (incomplete). As these were atypical they, too, were discarded. This left two groups, i.e., 119 cases with unilateral clefts of lip and palate and 57 cases with bilateral clefts of lip and palate. Of the 119 unilateral cases, 19 had incomplete clefts of lip and alveolus and 100 had complete clefts of lip and alveolus. Of the 57 bilateral cases,

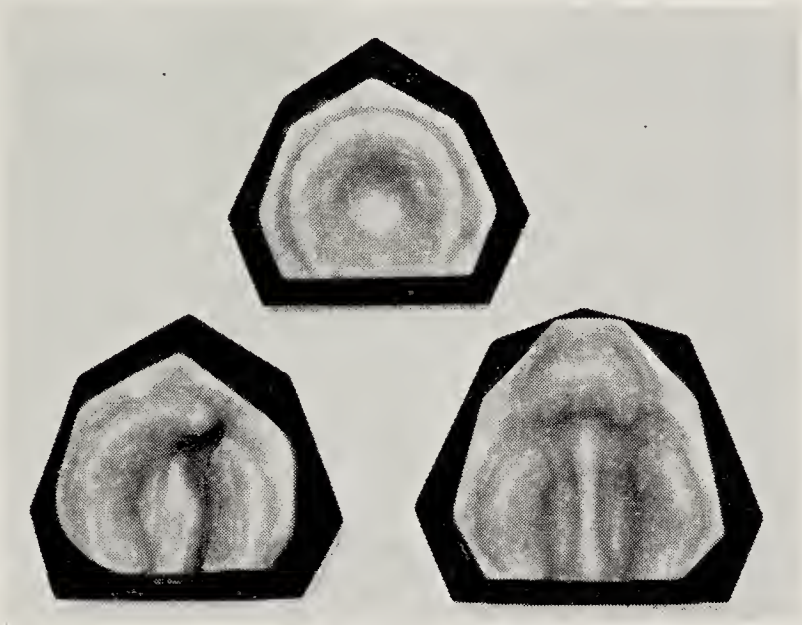

Fig. 1.—Three models of babies 3 days after birth. The top model has no cleft, the lower models have the types of unilateral and bilateral clefts investigated in this paper.

10 had incomplete clefts of lip and alveolus on one side, the other side being complete, the remaining 47 had complete clefts of lip and alveolus on both sides.

For the control group, 100 cases with Class III malocclusions were selected at random from patients under treatment at Raigmore Hospital, Inverness. The Great Ormond Street patients were drawn from the London area and also a few from other parts of England. The Inverness patients were partly local in origin, but many were from the South of Scotland and from England, Inverness being an administrative centre with the population constantly changing. Thus it seemed reasonable to compare the two groups, as both had varied genetic backgrounds.

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Fig. 1 shows three models of babies soon after birth. The first has no cleft, the second and third show the types of unilateral and bilateral clefts respectively which were investigated. The patients examined were all between 8 and 14 years of age, all having permanent incisors and first permanent molars erupted although mainly having mixed dentitions.

the classification. This was straightforward enough in the non-cleft cases, but in the cleft cases the 'A' point is sometimes difficult to determine accurately and then only an approximate measurement can be made. Unfortunately, it is usually the cases with indeterminate 'A' points which also have dilaceration of, or sometimes absent, incisors, so that the correction of

Table I.—A Comparison of Skeletal Relationships in Occlusal Class III Cases

Type of Occlusal Class III	Skeletal Classification			
	I	II (mild)	III (mild)	III
No Clefts (Total=100)	14 (14·0 per cent)	0 (0 per cent)	70 (70·0 per cent)	16 (16 per cent)
Unilateral Clefts (Total=119)	15 (12·6 per cent)	6 (5·0 per cent)	83 (69·8 per cent)	15 (12·6 per cent)
Bilateral Clefts (Total=57)	5 (8·8 per cent)	1 (1·8 per cent)	17 (29·8 per cent)	34 (59·6 per cent)

Table II.—Gonial Angles in Occlusal Class III Cases

Type of Case	Gonial Angles				
	<117°	118–122°	123–127°	128–132°	>133°
No Clefts (Total=100)	3 (3·0 per cent)	19 (19·0 per cent)	37 (37·0 per cent)	38 (38·0 per cent)	3 (3·0 per cent)
Unilateral Clefts (Total=119)	7 (5·9 per cent)	27 (22·7 per cent)	37 (31·1 per cent)	29 (24·4 per cent)	19 (15·9 per cent)
Bilateral Clefts (Total=57)	2 (3·4 per cent)	4 (7·0 per cent)	18 (31·6 per cent)	20 (35·2 per cent)	13 (22·8 per cent)

All the Class III cases compared had at least one half unit of prenormality of the posterior occlusion and the overjets were either completely reversed, reversed but with one or more teeth in labial occlusion, or edge to edge.

All the cleft and non-cleft cases were examined clinically, from models and radiographs, and also from cephalometric radiographs. The cleft cases were examined by Professor Walther and myself, but the non-cleft cases only by myself.

The skeletal relationships were examined, the soft-tissue environments, and then the occlusions themselves.

SKELETAL DIFFERENCES

Skeletal Classification (*Table I*)

The skeletal relationships were assessed clinically and then by cephalometric radiographs. The correction of incisor angles method and also the SNA–SNB differences were used to determine incisor angles method is not very accurate either. However, this method together with the clinical assessment can usually produce a rough estimate, although not too much attention should be paid to small angular differences.

It will be seen (from *Table I*) that the 100 non-cleft cases were usually (70 per cent) mild skeletal Class III, with almost equal numbers of severe Class III and normal relationships (16 per cent and 14 per cent respectively). None had a class II relationship. The normal ones were all tending towards a mild Class III rather than in the other direction. It is interesting that the unilateral clefts (i.e., the less severe clefts) had almost the same percentage of mild Class III (69·8 per cent), and similar for the severe Class III (12·6 per cent) and Class I (12·6 per cent), although a few (5 per cent) had a very mild Class II skeletal relationship. However, in the severe cleft cases (i.e., the bilateral cases) a much lower percentage were mild Class III (29·8 per cent) while a much

higher percentage were a severe skeletal Class III (59·6 per cent). The Class I relationships were lower than with other groups (8·8 per cent) but there was just one (1·8 per cent) with a mild Class II relationship. The cases with the mild Class II relationships had very severely tilted teeth, which is the reason for the Class III occlusion.

ment are grouped into five columns, viz., less than 20°, 21–24°, 25–29°, 30–33°, and above 34°. In the non-cleft group the majority (47·0 per cent) had values between 25–29° and the remainder were mainly (28·0 per cent) in the 30–33° range. Only 10 per cent were above 34° and only 15 per cent below 24°. Only 3 per cent were below 20°.

Table III.—Frankfurt-Mandibular Angles in Occlusal Class III Cases

Type of Case	Frankfurt-Mandibular Angles				
	<20°	21–24°	25–29°	30–33°	>34°
No Clefts (Total=100)	3 (3·0 per cent)	12 (12·0 per cent)	47 (47·0 per cent)	28 (28·0 per cent)	10 (10·0 per cent)
Unilateral Clefts (Total=119)	9 (7·6 per cent)	13 (10·9 per cent)	42 (35·3 per cent)	31 (26·0 per cent)	24 (20·2 per cent)
Bilateral Clefts (Total=57)	2 (3·4 per cent)	14 (24·6 per cent)	13 (22·8 per cent)	14 (24·6 per cent)	14 (24·6 per cent)

Table IV.—Facial Proportions in Occlusal Class III Cases

Type of Case	Facial Proportions (N–S/Facial Height per cent)				
	<54 per cent	55–59 per cent	60–64 per cent	65–69 per cent	>70 per cent
No Clefts (Total=100)	4 (4·0 per cent)	17 (17·0 per cent)	30 (30·0 per cent)	34 (34·0 per cent)	15 (15·0 per cent)
Unilateral Clefts (Total=119)	11 (9·2 per cent)	40 (33·6 per cent)	46 (38·8 per cent)	19 (15·9 per cent)	3 (2·5 per cent)
Bilateral Clefts (Total=57)	2 (3·4 per cent)	22 (38·5 per cent)	27 (47·4 per cent)	5 (8·9 per cent)	1 (1·8 per cent)

Gonial Angle (*Table II*)

The gonial angles were measured in the three groups from cephalometric radiographs. In *Table II* the angles have been grouped at 5° intervals with 5 groups varying from less than 117° to over 133°. The non-cleft cases were equally distributed between 123–127° (37·0 per cent) and 128–132° (38 per cent), the remainder being between 118–122° (19·0 per cent). Only 3 per cent were above 133° and only 3 per cent below 117°. The unilateral clefts showed wider distribution and more (15·9 per cent) in the highest groups (above 133°), and the bilateral cases even wider distribution, with 22·8 per cent in the highest group, one being as high as 140°.

Frankfurt-Mandibular Angle (*Table III*)

The Frankfurt-mandibular-planes angles were measured from cephalometric radiographs and compared in the three groups. In *Table III* the values for the Frankfurt-mandibular measure-

The unilateral cleft group showed a wider distribution. Only 35·3 per cent were between 25–29°. The rest were mainly above this (26·0 per cent between 30–33° and 20·2 per cent above 34°) with 18·5 per cent below 24° and of these 7·6 per cent were below 20°.

The bilateral clefts showed almost equal distribution amongst the values. 24·6 per cent were between 21–24°, 22·8 per cent between 25–29°, 24·6 per cent between 30–33°, and 24·6 per cent above 34°. Only 3·4 per cent were below 20°.

The three groups show different distribution patterns and cleft cases showed greater variation than non-cleft cases. The distribution patterns are similar to those of the gonial angle.

Facial Proportions (Nasion–Sella/Facial Height per cent) (*Table IV*)

The facial proportions were measured from cephalometric radiographs by measuring the

facial height from nasion to gnathion and measuring the length from nasion to sella, then expressing the proportion as a percentage of N–S/Facial height. A lower value would mean a long face or a short N–S length. A high value would mean a short face or a long N–S length. By using percentages the cases may be compared. The results are seen in *Table IV*. Most of the values fall between 55–69 per cent, a few under 54 per cent, and just a few over 70 per cent. non-cleft cases show less variation from normal than the cleft cases and of the cleft cases the bilateral group showed greater variation than the unilateral group. Thus it would seem that the skeletal background of the more severe clefts varies far more than in the other two groups. These differences in basic skeletal relationship are important when considering the treatment in the cleft cases and could account for the lack of success with many of those cases.

Table V.—Mandibular Posture and Movements in Occlusal Class III Cases

Type of Case	Interocclusal Clearance			Path of Closure				During Swallowing	
	Normal	Increased Moderate	Increased Severe	Normal	Pro-trusive	Lateral Right	Lateral Left	Tooth-apart	Tooth-together
No Clefts (Total=100)	44 (44·0%)	31 (31·0%)	25 (25·0%)	32 (32·0%)	62 (62·0%)	5 (5·0%)	1 (1·0%)	41 (41·0%)	59 (59·0%)
Unilateral Clefts (Total=119)	52 (43·7%)	37 (31·1%)	30 (25·2%)	76 (63·9%)	40 (33·6%)	1 (0·8%)	2 (1·7%)	55 (46·2%)	64 (53·8%)
Bilateral Clefts (Total=57)	14 (24·6%)	20 (35·1%)	23 (40·3%)	46 (80·7%)	10 (17·5%)	1 (1·8%)	0 (0%)	34 (59·7%)	23 (40·3%)

Table VI.—A Comparison of Active Lip Line in Occlusal Class III Cases

Type of Case	Active Lip Line		
	High	Average	Low
No Clefts (Total=100)	7 (7·0 per cent)	54 (54·0 per cent)	39 (39·0 per cent)
Unilateral Clefts (Total=119)	16 (13·5 per cent)	75 (63·0 per cent)	28 (23·5 per cent)
Bilateral Clefts (Total=37)	4 (10·8 per cent)	18 (48·7 per cent)	15 (40·5 per cent)

The bilateral cases all fall between 55–64 per cent except 2 below and 6 above, with the majority in the middle grouping (47·4 per cent of cases). The unilateral cases showed more variation but still had most in the 55–64 per cent range but with 9·2 per cent of cases below and 18·4 per cent above. The non-clefts were mainly in the higher range from 60–69 per cent, with even higher values (15 per cent of cases over 70 per cent) and fewer lower values (4 per cent of cases), and with 17 per cent of cases in the 55–59 per cent group.

Conclusions from Skeletal Measurements

By comparing these three groups for skeletal classification, gonial and Frankfurt-mandibular angles, and facial proportions, it is seen that the

MANDIBULAR POSTURE AND MOVEMENTS

Interocclusal Clearance (*Table V*)

The interocclusal clearance was measured clinically, normal being taken as 2–4 mm. in the premolar region. The non-cleft and unilateral cases were very similar, but the bilateral cases showed a much higher percentage with increased interocclusal clearance (*see Table V*), but fewer normal cases. This is possibly due to the extreme lack of maxillary development, which is more marked in these cases.

Position during Swallowing

Almost half the cases in each group had a tooth-together swallowing action and half a

tooth-apart. The non-cleft had rather more tooth-together, while the bilateral cases had rather more tooth-apart. However, there is no marked difference (*see Table V*).

Paths of Closure (*Table V*)

The paths of closure were assessed clinically and classified as normal (with no deviation), protrusive, or lateral right or left. There are very few with lateral deviations. The non-cleft cases had the majority of protrusive path of closure, while the bilateral cleft cases had very few. This is because the bilateral cases had the more severe reverse overjets. From *Table V*, the bilateral cases would appear to be the most normal. However, these 'normal' paths of closure (i.e., lacking in deviation) were associated with increased inter-occlusal clearance and were, therefore, actually cases of over-closure and not truly normal.

DIFFERENCES IN SOFT-TISSUE ENVIRONMENT

The soft tissues were assessed clinically. The lip lines related to maxillary incisors at rest and during swallowing and speech, and the contraction of upper and lower lips was checked. The level of the tongue in relation to the occlusal plane and the tongue action during swallowing and speech were assessed.

Lip Line (*Table VI*)

The active lip line was measured when the lips were in contact. Average was considered to be the lower third to half of the clinical crown of the most normal maxillary incisor. Twenty of the bilateral cases had no maxillary incisors and were eliminated from this assessment, leaving only 37 in this group. It is seen that the non-cleft and bilateral cases show a similar distribution, although the unilateral cases have a higher percentage with the high and average lip lines, but less with a low lip line.

Lip Action (*Table VII*)

The contraction of the lips was checked clinically when the lips were held together, during speech and during swallowing. The contraction was judged as either absent, slight, moderate or excessive. In the cleft cases where the upper lip

Table VII.—Lip Contraction in Occlusal Class III Cases

Type of Case	Degree of Lip Contraction			
	No Contraction	Slight	Moderate	Excessive
No Clefts (Total=100)	2 (2·0 per cent)	63 (63·0 per cent)	32 (32·0 per cent)	3 (3·0 per cent)
Unilateral Clefts (Total=119)	5 (4·2 per cent)	69 (58·0 per cent)	30 (25·2 per cent)	15 (12·6 per cent)
Bilateral Clefts (Total=57)	2 (3·5 per cent)	30 (52·7 per cent)	10 (17·5 per cent)	15 (26·3 per cent)

Table VIII.—Tongue Position and Action in Occlusal Class III Cases

Type of Case	Position			Anterior Tongue Thrust			Swallowing and Tongue Thrusts	
	High	Average	Low	Slight	Severe	Absent	Tooth-together with Thrust	Tooth-apart with Thrust
No Clefts (Total=100)	19 (19·0%)	49 (49·0%)	32 (32·0%)	50 (50·0%)	5 (5·0%)	45 (45·0%)	27 (27·0%)	28 (28·0%)
Unilateral Clefts (Total=119)	15 (12·6%)	81 (68·1%)	23 (19·3%)	48 (40·3%)	12 (10·1%)	59 (49·6%)	28 (23·5%)	32 (26·9%)
Bilateral Clefts (Total=57)	3 (5·3%)	25 (43·8%)	29 (50·9%)	18 (31·6%)	7 (12·3%)	32 (56·1%)	13 (22·8%)	12 (21·1%)

was deficient there was excessive contraction to overcome this. However, from *Table VII*, it will be seen that the types of circumoral contraction are more alike in the non-cleft and unilateral cases, than in the bilateral cases. All these groups have a very low percentage showing no contraction at all. Most of the cases show only a slight degree of contraction (63·0 per cent, 58·0 per cent, and 52·7 per cent respectively of the non-cleft, unilateral, and bilateral groups). A greater number with moderate and excessive contraction is seen in the cleft cases, most being seen in the bilateral cases.

Tongue Position (*Table VIII*)

The tongue position was examined clinically and from lateral skull radiographs, and the position assessed as being either high, average, or low in relation to the occlusal plane. The non-cleft cases were mainly average (49 per cent) but with quite a high percentage of low (32 per cent) and with the remainder (19 per cent) high. In the cleft cases there were fewer high (12·6 per cent) in the unilateral and (5·3 per cent) in the bilateral, which would seem to tie up with the more retroclined incisors. The bilateral cases showed many more low tongue positions, while the unilateral cases showed more average levels.

Tongue Action (*Table VIII*)

The tongue action during speech and swallowing was assessed clinically. The majority of cases in all three groups had either no thrusts or only slight thrusts. Severe tongue thrusts were rare in all groups. The tongue thrusts had almost half with tooth-apart and half with tooth-together swallowing in all three groups.

The severe tongue thrusts with tooth-together swallowing were associated with anterior open bite in all three groups.

The main differences in the soft tissues would seem to be connected with the lack of mobility in the upper lip, especially in the bilateral cases, which cause a greater contraction of the lower lip in order to compensate. The low tongue position together with this contraction would produce greater retroclination of incisors in these cases, and also prevent the complete correction of the incisors. There is also often constant pressure from the scar tissue.

OCCLUSAL RELATIONSHIPS

The occlusions were examined clinically, and on models, and the incisor angles were measured from cephalometric radiographs.

The labial segments were assessed for incisor angulation, and overjet and overbite. The posterior segments were assessed for anterior-posterior and lateral positioning. The presence of crowding was checked and also the absence of

Table IX.—A Comparison of the Inclination of Maxillary Incisors to Frankfurt Plane in Occlusal Class III Cases

Type of Occlusal Class III	Inclination of Maxillary Incisors to Frankfurt Plane															
	51–55°	56–60°	61–65°	66–70°	71–75°	76–80°	81–85°	86–90°	91–95°	96–100°	101–105°	106–110°	111–115°	116–120°	121–125°	126–130°
No Clefts (Total=100)	0	0	0	0	0	0	0	0	1 (1%)	8 (8%)	23 (23%)	28 (28%)	23 (23%)	14 (14%)	1 (1%)	2 (2%)
Unilateral Clefts (Total=119)	0	0	0	1 (0·8%)	3 (2·5%)	6 (5·0%)	8 (6·7%)	17 (14·3%)	17 (14·3%)	22 (18·5%)	18 (15·1%)	12 (10·1%)	12 (10·1%)	2 (1·7%)	0	1 (0·8%)
Bilateral Clefts (Total=37)	3 (8·1%)	0	2 (5·3%)	2 (5·3%)	2 (5·3%)	5 (13·7%)	3 (8·1)%	5 (13·7%)	7 (19·1%)	2 (5·3%)	3 (8·1%)	2 (5·3%)	1 (2·7%)	0	0	0

teeth and the existence and position of supernumerary teeth.

Labial Segments

The Inclination of Maxillary Incisors

The inclinations of maxillary incisors to the Frankfurt plane were measured in all the groups. They were checked clinically and then the angulation measured on cephalometric radiographs. The most normal central incisors were taken in each case and not the dilacerated ones. In the case of the bilateral (Veau IV) clefts the incisors were missing or severely dilacerated in 20 of the 57 cases. Therefore, only 37 could be measured accurately. In the other cases there was at least one of the central incisors sufficiently normal to be measured.

The Frankfurt plane was used in preference to the maxillary plane partly because it is easier to assess clinically, but mainly because the anterior and posterior nasal spines are difficult to determined in the cleft palate cases and in the more severe types neither of these points exist at all.

In *Table IX* the measurements of the angulation of maxillary incisors are compared in the three groups, the actual number of cases are shown, and then the percentages of the total shown in brackets underneath. Each column has a range of 5°. No angles below 51° or above 130° were measured in any of the groups.

The non-cleft group shows no cases with the angulation of less than 91° and only one in this column, and only 8 in the next column (96–100°). The majority of the cases have angulations varying from 101 to 115° (74 per cent), i.e., within reasonably normal limits, with 9 per cent below and the remainder (17 per cent) above 116°. Of the higher values, the majority were between 116–120° and only 3 above 120°. The other two groups show a much wider distribution, with the values spread out and not concentrated within the 101–115° range as in the non-cleft group. In the unilateral (Veau III) cases, the lowest angle measured was in the 66–70° range and nothing below 66°. In the higher range there were only 3 above 115°.

In the bilateral cases the angulations were widely spread, the lowest being in the 51–55° range, the highest in the 111–115° range. There is no definite concentration in one range.

The Inclination of the Mandibular Incisors to the Mandibular Plane

The inclinations of the mandibular incisors to the mandibular plane were measured in all the three groups. They were checked clinically and the actual measurements made on cephalometric radiographs. In this instance all the cases could be measured and 57 cases were measured in the bilateral group.

In *Table X* the measurements of angulation of mandibular incisors to mandibular plane are compared in the three groups. Again, each column has a range of 5°. The lowest angle measured was 65° and the highest 105°. Again, the non-cleft cases were mainly grouped in the columns approximating to normal (90°), or 10° below, or 5° above. Thus the teeth were tending to be more retroclined than normal, but not entirely so. Eighty-four per cent of the cases were between 81–95°. Only 8 per cent were above 96° and the highest value 105°. Only 8 per cent were below 80° and none below 76°.

In the unilateral clefts (Veau III cases), the greater spread of cases is seen and a tendency to more retroclination than in the non-cleft cases. Only 4 (3·4 per cent) were above 96° and none over 100°. However, 53 cases (44·6 per cent) were below 80°, the lowest value being 4 (3·4 per cent) in the 65–70° range.

In the bilateral cases, again there was a wide spread over the range from 65 to 100° with none over 100°. Only 12 (21 per cent) were between 86–95°, or with normal values. The majority (32 cases or 56 per cent) were between 76–85° and a further 10 (17·5 per cent) were between 65–75°.

Table X.—A Comparison of the Inclination of Mandibular Incisors to Mandibular Plane in Occlusal Class III Cases

Type of Occlusal Class III	Inclination of Mandibular Incisors to Mandibular Plane							
	65–70°	71–75°	76–80°	81–85°	86–90°	91–95°	96–100°	101–105°
No Clefts (Total=100)	0	0	8 (8·0%)	26 (26·0%)	33 (33·0%)	25 (25·0%)	7 (7·0%)	1 (1·0%)
Unilateral Clefts (Total=119)	4 (3·4%)	16 (13·5%)	33 (27·7%)	26 (21·8%)	19 (15·9%)	17 (14·3%)	4 (3·4%)	0
Bilateral Clefts (Total=57)	2 (3·5%)	8 (14·0%)	14 (24·6%)	18 (31·6%)	8 (14·0%)	4 (7·0%)	3 (5·3%)	0

Thus the angulations of maxillary and mandibular incisors followed similar patterns. The non-cleft cases showed far less variation from normal, while the cleft cases, particularly the bilateral cases, showed extreme retroclination of the mandibular incisors as well as of the maxillary incisors.

26 per cent ' normal '. In the unilateral cleft cases a higher percentage were in reverse overjet (75·6 per cent), very few edge to edge (5·9 per cent), and rather less (18·5 per cent) ' normal '.

Of the bilateral cases, the majority (89·2 per cent) were reversed, with only one edge to edge and 3 ' normal ' cases.

Table XI.—A Comparison of Incisor Overjet in Occlusal Class III Cases

Type of Occlusal Class III	Type of Incisor Overjet			
	Reversed	Edge to Edge	' Normal '	Increased
No Clefts (Total=100)	49 (49 per cent)	25 (25 per cent)	26 (26·0 per cent)	0
Unilateral Clefts (Total=119)	90 (75·6 per cent)	7 (5·9 per cent)	22 (18·5 per cent)	0
Bilateral Clefts (Total=37)	33 (89·2 per cent)	1 (2·7 per cent)	3 (8·1 per cent)	0

Table XII.—A Comparison of Incisor Overbite in Occlusal Class III Cases

Type of Occlusal Class III	Type of Incisor Overbite				
	Anterior Open Bite	Edge to Edge Bite	Reduced Overbite	Normal	Increased Overbite
No Clefts (Total=100)	5 (5·0 per cent)	25 (25·0 per cent)	14 (14·0 per cent)	35 (35·0 per cent)	21 (21·0 per cent)
Unilateral Clefts (Total=119)	9 (7·6 per cent)	23 (19·3 per cent)	20 (16·8 per cent)	36 (30·3 per cent)	31 (26·0 per cent)
Bilateral Clefts) (Total=37)	7 (19·1 per cent)	3 (8·1 per cent)	8 (21·1 per cent)	4 (10·6 per cent)	15 (41·1 per cent)

Overjet

The incisor overjets were measured clinically and checked on cephalometric radiographs. They were divided into ' normal ', edge to edge, and reversed. No cases had increased overjet.

Table XI shows the number of cases with each type of incisor overjet, with the percentage of the total number of cases underneath in brackets. In the bilateral cases, 20 cases had absent or severely dilacerated incisors and these could not be accurately assessed. Therefore, only 37 cases were assessed for overjet in this group.

The ' normal ' groups consist of cases with at least one central incisor in labial occlusion with the lower incisors. In very few cases were all four incisors in labial occlusion, but have been called ' normal ' for the sake of convenience. Usually one or two lateral incisors, or the other central incisor, were in lingual occlusion.

In the non-cleft cases, 49 per cent were completely reversed, 25 per cent edge to edge, and

Overbite

The incisor overbite was then considered in a similar way (*see Table XII*), and only 37 of the bilateral cases could be measured due to absent or dilacerated maxillary incisors. The overbites were grouped as anterior open bite, reduced overbite, edge to edge, increased, or normal.

Of the non-cleft cases, the majority were normal (35 per cent) or edge to edge (25 per cent), with a large number of increased as well (21 per cent). Only 5 per cent had open bite but 14 per cent had reduced overbite. Of the unilateral cleft cases, there was a similar distribution, with only a difference of at the most 5 per cent in any one group. Of the bilateral cleft cases, nearly half (41·1 per cent) had an increased overbite while at the other end of the scale the same (48·3 per cent) had anterior open bite, reduced overbite, or edge to edge. Only 10·6 per cent were near to normal. Thus there seems to be a greater difference in the

bilateral cases, there being the two different types of abnormality with few of the nearly normal types.

Posterior Occlusion (*Table XIII*)

The posterior occlusion was examined clinically and from models. The cross-bites were classified according to whether they occurred on the right side only, the left side only, or bilaterally. They were then subdivided according to whether the whole maxillary buccal segment was in cross-bite or whether it was just in cross-bite in the premolar region. It was found that the majority of the non-cleft cases had no posterior cross-bites and if any were present they tended to be bilateral, only a few being unilateral. In the cleft cases, the unilateral cases had more unilateral cross-bites than bilateral, but the unilateral ones were mainly present in the premolar region and not complete cross-bites. Where the bilateral cross-bites occurred, they were mainly complete. In the bilateral cases, most had bilateral cross-bite either complete or in the premolar region. Very few (3·4 per cent) had no posterior cross-bite at all.

Crowding

The existence of crowding was checked clinically and then measured on models. Unerupted teeth were checked from radiographs. The maxillary and mandibular arches were assessed separately as shown in *Table XIV*. No case in any group showed spacing in both arches. The majority of all cases (47·0 per cent of non-cleft, 47·9 per cent of unilateral clefts, and 45·6 per cent of bilateral cleft cases) showed crowding in the maxillary arch but with no crowding in the mandibular arch; however, nearly as many (42·0 per cent of the non-clefts, 37·0 per cent of the unilateral cleft cases, and 43·9 per cent of the bilateral cleft cases) showed crowding in both arches. Only a few in each group showed spacing

Table XIII.—A Comparison of Posterior Cross-bites in Occlusal Class III Cases

Type of Case		Right		Left		Bilateral		
	None	Whole Segment	Premolar Region	Whole Segment	Premolar Region	Whole Segments	Premolar Regions	One Side Whole Segment, Other Side, Premolar Region
No Clefts (Total=100)	60 (60·0%)	7 (7·0%)	3 (3·0%)	3 (3·0%)	3 (3·0%)	18 (18·0%)	6 (6·0%)	0
Unilateral Clefts (Total=119)	29 (24·4%)	3 (2·5%)	20 (16·8%)	7 (5·9%)	33 (27·7%)	22 (18·5%)	2 (1·7%)	3 (2·5%)
Bilateral Clefts (Total=57)	2 (3·4%)	2 (3·4%)	1 (1·8%)	3 (5·3%)	1 (1·8%)	31 (54·4%)	9 (15·9%)	8 (14·0%)

Table XIV.—A Comparison of the Tooth/Tissue Disproportion in Occlusal Class III Cases

Type of Case	Spacing in Maxillary and Mandibular Arches	Spacing in Mandibular Arch: Maxillary Arch in Proportion	Crowding of Maxillary Arch: Mandibular Arch in Proportion	Crowding in Both Arches	Crowding in Maxillary Arch: Spacing in Mandibular Arch
No Clefts (Total=100)	0	5 (5·0 per cent)	47 (47·0 per cent)	42 (42·0 per cent)	6 (6·0 per cent)
Unilateral Clefts (Total=119)	0	6 (5·0 per cent)	57 (47·9 per cent)	44 (37·0 per cent)	12 (10·1 per cent)
Bilateral Clefts (Total=57)	0	2 (3·5 per cent)	26 (45·6 per cent)	25 (43·9 per cent)	4 (7·0 per cent)

in the mandibular arch but with the maxillary arch either in proportion or crowded.

The degree of crowding and distribution of the crowding is very similar in the three groups with hardly any variation. Thus the crowding would probably have been present in the cleft cases had no clefts occurred.

as I had seen most of the children myself through the mixed dentition period and had direct contact with the general dental practitioners. However, in the case of the cleft cases the histories were, unfortunately, not so clear. In many cases teeth had been extracted during surgery. This often occurs and is not noted.

Table XV.—Congenitally Absent Teeth in Occlusal Class III Cases

Type of Occlusal Class III	Maxillary Lateral Incisors		Maxillary Second Premolars		Mandibular Second Premolars		Mandibular Incisors	More Than Two	None
	Unilateral	Bilateral	Unilateral	Bilateral	Unilateral	Bilateral			
No Clefts (Total=100)	1 (1%)	4 (4%)	2 (2%)	0	2 (2%)	2 (2%)	1 (1%)	1 (1%)	88 (88%)
Unilateral Clefts (Total=119)	89 (73·9%)	4 (3·4%)	3 (2·5%)	2 (1·7%)	3 (2·5%)	3 (2·5%)	2 (1·7%)	20 (16·8%)	26 (21·8%)
Bilateral Clefts (Total=37)	4 (10·6%)	19 (51·4%)	1 (2·7%)	0	1 (2·7%)	1 (2·7%)	1 (2·7%)	4 (10·6%)	7 (19·1%)

Table XVI.—Distribution of Supernumeraries in the Cleft Line and the Association with Absent Lateral Incisors in Occlusal Class III Cases

Type of Cleft Case	Total No. of Cases with Supernumeraries in the Cleft Line	Position of Supernumerary						No. of Cases with Absent Lateral Incisors and Supernumeraries	No. of Cases with no Absent Teeth	No. of Cases with History of Extraction of Incisors (% of whole total)
		Distal of Cleft Line		Mesial of Cleft Line		Both Mesial and Distal of Cleft Line				
		Unilateral	Bilateral	Unilateral	Bilateral	Unilateral	Bilateral			
Unilateral Clefts (Total=119)	52 (43·7% of 119 cases)	37 (71·2%)	0	5 (9·6%)	0	10 (19·2%)	0	41 (78·9%)	11 (21·1%)	0
		Percentages shown are of 52 cases								
Bilateral Clefts (Total=57)	20 (33·7% of 57 cases)	9 (45%)	5 (25·0%)	1 (5·0%)	2 (10·0%)	1 (5·0%)	2 (10·0%)	17 (85·0%)	3 (15·0%)	20 (33·7% of 57 cases)
		Percentages shown are of 20 cases								

Absent Teeth and Supernumeraries

The congenital absence of teeth was checked clinically, from radiographs, and from previous dental histories. In the non-cleft group, the decision that a tooth was congenitally absent and not extracted was almost certain to be accurate,

Table XV shows the teeth found to be congenitally absent in these groups. Of the non-cleft cases, 12 per cent had absent teeth; these were made up of 5 per cent with missing maxillary lateral incisors, (unilateral in 1 and bilateral in 4 cases) 6 per cent with missing second premolars, and just 1 case with an absent mandibular

incisor. In 1 case of the 12, more than two teeth were absent and this was a case of partial anodontia with lateral incisors and second premolars all absent. I have disregarded third molars as some of the patients may have developed some later on.

In the unilateral cleft cases, 73·9 per cent had an absent maxillary lateral incisor on the side of the cleft lip and alveolus, and 3·4 per cent had bilateral absence of maxillary lateral incisors. The incidence of absent premolars and absent mandibular incisors seems to be similar to that in the non-cleft cases.

In the bilateral cleft cases, only 37 could be included in this examination as 20 had histories of dental extractions but the teeth not identified. Of the 37, 51·4 per cent had maxillary lateral incisors absent in the cleft lines on both sides; 10·6 per cent had them absent on one side but present on the other. Again, the absence of premolars shows a similar distribution. Thus it would appear that the only difference is the absence of maxillary incisors in the cleft lines.

However, the presence of supernumeraries was also checked from clinical examination and radiographs. It was found that in the non-cleft cases, no supernumeraries were present at all, and the cleft cases only had supernumeraries present in the cleft line. The question of whether these were true supernumeraries or just reduced lateral incisors is difficult to determine when the lateral incisors are absent. If they were not supernumeraries but reduced lateral incisors, then the number of truly absent lateral incisors would be greatly reduced.

Of the unilateral cleft cases, 52 (43·7 per cent) had supernumeraries present in the cleft line, and of the bilateral cases, 20 (33·7 per cent) had them present. In *Table XVI* the distribution of these supernumeraries is seen, according to whether they were mesial or distal to the cleft line and which cases had them mesially and distally in the same cleft. The percentages shown are of the total number of cases with supernumeraries and not of the whole number of cases in each group.

It is seen that they occur more often distally to the cleft line than mesially, although quite a few (19·2 per cent and 15·0 per cent) had them both mesially and distally. The number of cases with supernumeraries and absent lateral incisors is seen to be as high as 78·9 per cent in the unilateral cleft cases and 85·0 per cent in the bilateral cleft cases.

If these figures are compared with those for absent teeth, 41 unilateral cases had absent lateral incisors and supernumeraries, 93 had absent lateral incisors, then 52 had absent lateral incisors but no supernumeraries. Of the bilateral cases, 17 had absent lateral incisors and supernumeraries present. As 23 altogether had absent lateral incisors, then only 6 had absent lateral incisors without having any supernumeraries. If the so-called supernumeraries are in fact reduced and dilacerated lateral incisors, then it will be seen that fewer cases in fact had definitely absent lateral incisors than would appear at first. Then, also taking into account the destruction of tooth germs at the time of surgery and subsequent extraction with no noted histories, it was quite likely that, in fact, the incidence of congenitally absent lateral incisors is very little different from that in non-cleft cases. In view of the fact that the absence of premolars follows a similar pattern, in the three groups, this seems quite likely. Also, if this is true, it means that the incidence of supernumeraries is lower as well.

CONCLUSIONS

From this assessment it is seen that there is considerable variation in the three groups. Although the malocclusions may seem to be very similar when seen just on study models, there are, in fact, considerable differences which will affect the treatment planning. The main differences are as follows:—

1. The more severe the cleft, the more the skeletal relationships tend to vary from normal. More have severe skeletal Class III relationships, and higher values for gonial and Frankfurt-mandibular angles.
2. The more severe the cleft, the more difficult it is to determine the skeletal relationships accurately, which means that the prognosis is less certain.
3. Abnormal lip pressures are present which will tend to oppose any attempts to alter the incisor inclinations.
4. The reversed overjets are often too severe to be treated only by orthodontic means.
5. The scar tissue in the palate is liable to counteract any attempts to correct cross-bites, especially those confined to the premolar region.
6. The increased interocclusal clearance may allow relapse of any teeth moved over the bite.
7. The teeth are liable to be damaged in the cleft areas during surgical procedures.

Generally, the unilateral cleft cases may be treated along similar lines to the non-cleft cases, but with rather less chance of success. The prognosis for most of the bilateral cases with Class III malocclusions is usually poor if treated only by orthodontic means.

Acknowledgements

I should like to express my thanks to Professor D. P. Walther for permission to carry out this research project, which is based on some of his own work, and for his help and advice; also to Mr. T. Cradock-Henry and the Medical Committee at the Hospital for Sick Children, Great

Ormond Street, for permission to continue to visit the Dental Department there and to examine the records.

I should also like to thank Mr. C. Hunt, Medical Photographer, Raigmore Hospital, Inverness, for the slides and photographs.

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DISCUSSION

Mr. D. F. Glass thanked Miss Ridley for an interesting paper. The amount of work Miss Ridley had done was tremendous. He was sorry that she had no more cases.

The problem of cephalometrics in clefts was a big one as lateral radiographs did not mean a lot with clefts and the position of the SNA was doubtful. He always considered cephalometrics doubtful anywhere but with clefts it was more so.

On the problem of mandibular angle, children with bilateral clefts seemed to have a higher gonial angle than others. He thought that it was due to overactivity of the mandible which had to come out and close up a deficient maxilla. The lower lip was always over-developed and hence the retroclination of the lower incisors. He wondered what Miss Ridley thought about this.

He was sorry that Miss Ridley blamed the surgeon for the absence of certain teeth. He thought that modern plastic surgery was so good now that very little could be blamed on surgery. Certainly, tissue contraction was not usually due to surgery, but to tissue deficiency and the lateral incisors that were missing.

Miss Ridley thanked Mr. Glass for his comments. On the question of the small number of cases, she thought that there was quite a case for all the cleft centres to get together on this research because there were so many variations. She had thirteen groups of clefts and if these were divided into right and left clefts, and again into males and females, and one tried to get them at different stages of development, one was left with about half a dozen cases in each group, which meant nothing at all.

She had not really been blaming the surgeons but thought that it was a fact that teeth were removed or damaged, and no note was made of what had been done, so it was no use looking at the records. The surgery on most of the patients examined had been carried out more than seventeen years ago. There would have been some improvements since then.

Mr. A. G. Huddart referred to the question of cleft palate units collaborating to combine their records and said that one of the problems of research workers in this field was the acquisition of enough cases to make an acceptable series for study. If units were to collaborate there must be uniform and consistent record keeping at each individual centre, and it was no good making comparisons unless the records used were equivalent. If this could be done, however, it might be possible to start a central registry for the use of people working on particular projects, and this would be well worthwhile. He thought that the Society might take the initiative here and that if it was started now, a great deal could come out of such a scheme in the future.

With regard to the high gonial angle in cleft cases, Mr. Glass had said that this was due to lack of vertical growth of the maxilla. Referring back to Professor Moss's paper which he had found very stimulating, he wondered whether Miss Ridley or Professor Moss could suggest why deficient vertical growth occurred in these cases. What was wrong with the matrix?

Miss Ridley, in reply, said that she agreed on Mr. Huddart's first point and thought it was a very good idea.

With regard to gonial angles, these were all Class III occlusions and the non-cleft cases also showed high gonial angles. Of course, most of them were Skeletal IIIs and had small maxillae, so that the skeletal background was similar.

Professor M. L. Moss said that he wished to comment about cephalometrics. He was under the impression that the Frankfurt horizontal plane was a line designed by German anthropologists to help the German army keep their soldiers standing in exactly the same position! It was about time this nonsense was stopped.

On the problem of clefts, the primary defect in cases of cleft palate was an extreme kyphosis in the cranial base which set up in the fourth week of life. The general result was an inclination of the entire upper and middle face in regard to the nasal cavity in such a fashion that the posterior end was up and the anterior end was down and the posterior pharyngeal width was increased. This tended to give what looked like a prognathic lower jaw. It was not. It was a malpositioned maxilla.

With regard to the gonial angle, he did not know how that was measured, or what it was really. There were various ways of measuring it. He thought that it might be found that this angle was as it was because there had been a great change in the morphology of the pharynx. This would be found to be generally true; there had been a width increase and change in the morphology of the pharynx. The changes seen in this region tended in general to reflect the changes in functioning spaces in the pharynx.

A 'TROUBLE-FREE' TUBE ATTACHMENT FOR REMOVABLE APPLIANCE EXTRA-ORAL TRACTION

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THE advent of the Adams clasp revolutionized removable appliance design permitting the use of extra-oral traction and other techniques hitherto regarded as applicable to fixed appliances only. McCallin (1953), Adams (1955), Marx (1960), and Stevenson (1967) have all described methods of applying the traction to the appliance via buccal tubes attached to the premolar or molar Adams clasps. In this manner, the appliance can be worn on its own, for example by day, the traction, be it occipital or cervical, being added at night.

In my experience, this method has, however, certain disadvantages:—

1. The tube tends to stick out into the cheek and can be uncomfortable for the patient.

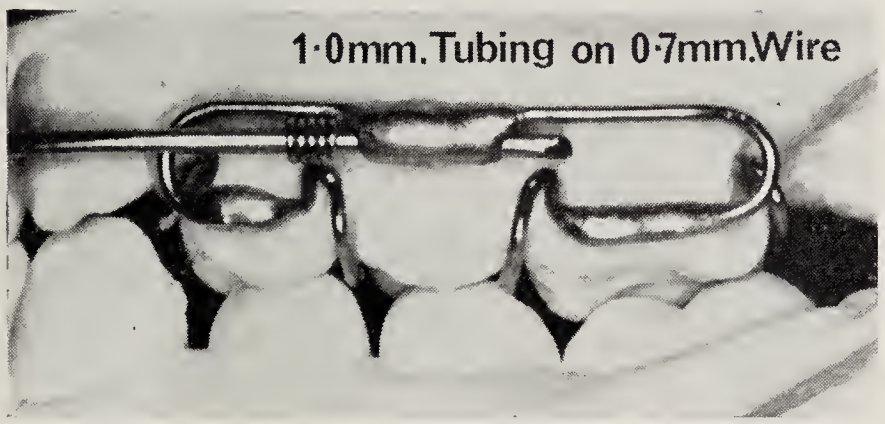
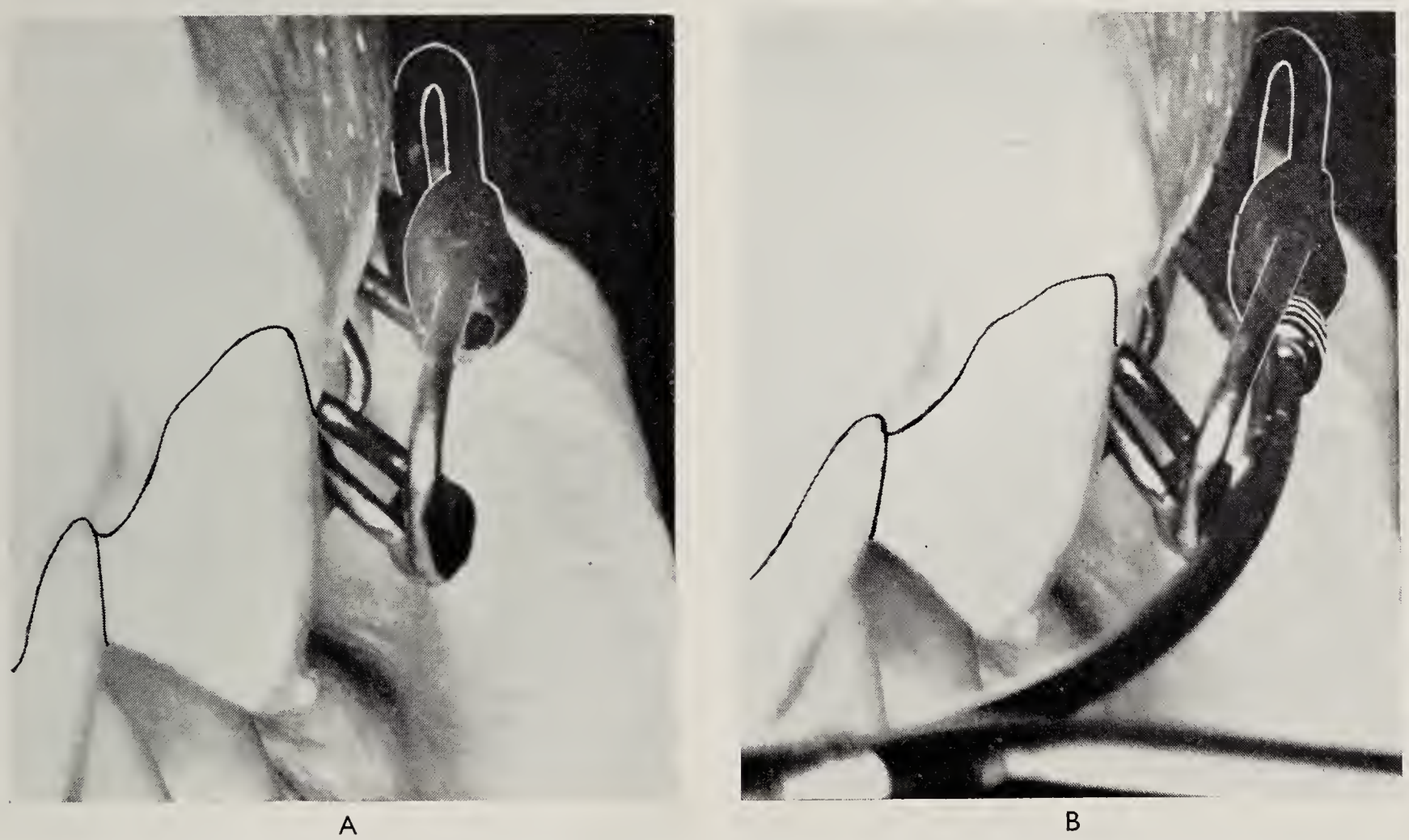


Fig. 1.—Loop in 0·7-mm. stainless-steel wire taped and soldered to premolar and molar Adams clasps with 1·0-mm. internal diameter tube attached. Trevor Johnson friction fit stop on arm can be replaced with 'U' adjustment loop as desired.



A B

Fig. 2.—A, End-on view to show how tube can be positioned almost directly beneath support wire. B, End-on view with extra-oral archwire in position.

Demonstration at the Jubilee Meeting held on 10 May, 1968.

2. When traction, particularly cervical traction, is applied it tends to distort the clasp so that it is no longer retentive and the appliance is pulled off the teeth.

3. The clasp has a tendency to fracture under load due to this distortion.

Extra-oral traction is commonly used to retract upper buccal segments or even whole upper

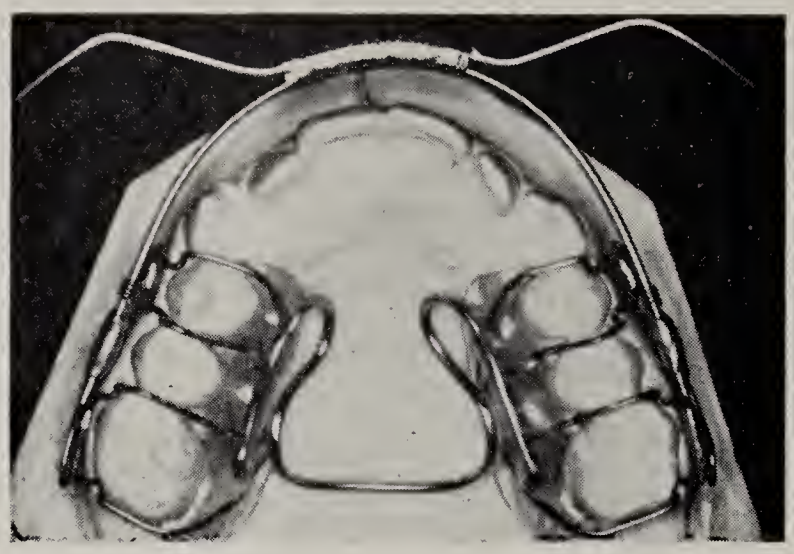


Fig. 3.—Plan view to show tubes faired in by support loops.

arches following the loss of upper second molars, for example in cases where the loss of first premolars would leave residual spacing or permit existing anterior spacing to deteriorate. In these cases, one commonly has first premolars and first molars available for clasping and, in order to overcome the problems mentioned, it is suggested that the tube be on a separate piece of 0·7-mm. wire, attached to both clasps. As shown in *Figs.* 1–3, this piece of wire is in the form of a loop attached to the bridge of each clasp with the tube situated midway between the two clasps, overlying the second premolar.

This method has the following advantages:—

1. The tube can be tucked in coronal to the loop wire, which itself acts as a fairing, presenting a streamlined contour to the cheek.

2. Application of traction to the tube is such that any displacing forces are equally shared by both clasps.

It has been our experience in this department that retention and breakage problems have been effectively reduced. Simple ready-made cervical headgear can be used in practically all cases, so that traction can be fitted at a routine short appointment.

Acknowledgements

I wish to thank Messrs. W. A. Nicol and D. Seel for their clinical evaluation of this modification. Also, Messrs. F. Gwynn and A. Chidgey for laboratory assistance, and Mr. J. Eatough, of the University of Bristol Medical Photographic Department, for the illustrations.

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PRESSURE EXERTED ON TEETH BY THE LIPS AND CHEEKS

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Lip and cheek pressures are recognized by most orthodontic textbooks as exerting some effect upon tooth position. It is known that a constant force as small as 4 grammes is sufficient to cause tooth movement (Weinstein, Haack, Morris, Snyder, and Attaway, 1963). It is probable that the oral soft tissues can exert steady forces of this size whilst in ' resting posture '. During swallowing, speech, and expressive behaviour much larger forces are exerted intermittently but the relationship of these forces to arch form remains unknown.

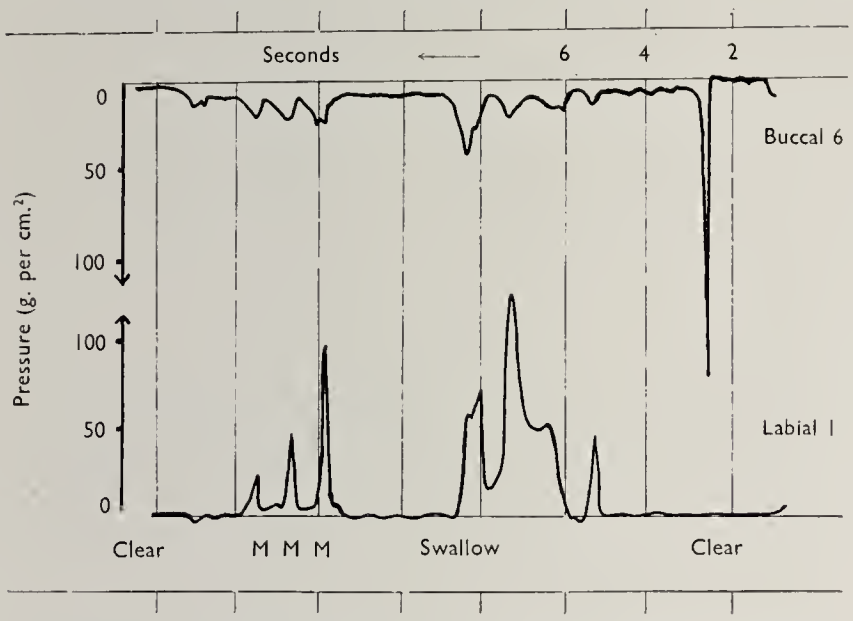

Fig. 1.—Tracing from a section of record chart showing one repetition of an exercise routine. The large peak at the beginning of the buccal trace is an artefact due to pressure from the subject's finger as he releases his cheek after holding it clear of the sensor to produce a base line. An event marker was used to mark the occurrence of each exercise by a dash on the record chart and ' swallow ' was marked at the moment of laryngeal elevation. This subject showed a steady buccal pressure but no labial pressure during ' rest '.

In this study lip and cheek pressures have been compared in three adult groups with different types of occlusion in an attempt to discover an association between pressure and arch form. The technique used for measuring intra-oral pressures has been previously described (Luffingham, 1968). The intra-oral sensors used were 5 mm. in diameter and were cemented directly onto the teeth so that they protruded between 1·5 and 2 mm. beyond the arch line. The sensor leads were soft vinyl tubing 1 mm. in diameter and were positioned to leave the mouth in the lip line and towards the angles of the mouth. This arrangement caused minimal interference with lip movement and subjects felt that there was no noticeable interference with the performance of the exercise routine.

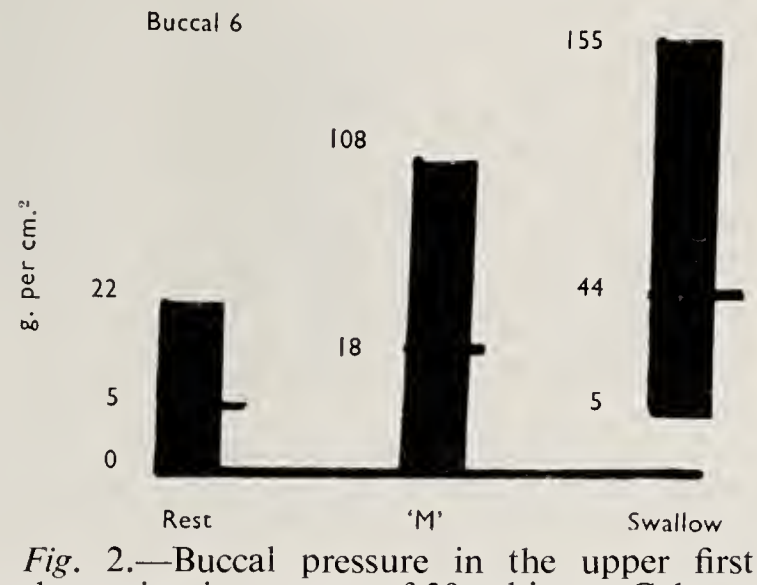

Fig. 2.—Buccal pressure in the upper first molar region in a group of 30 subjects. Column height shows the extreme range for each exercise, whilst the horizontal bar marks the mean pressure for the group.

Thirty subjects were chosen from amongst the students and staff at Guy's Hospital. Their ages ranged from 15 to 38 years old. All except one were male and none had undergone any recent orthodontic treatment or dental extraction.

Simultaneous recordings were made from two sensors placed against the maxillary arch, one in the central incisor region at mid-coronal level and one in the interdental space between the second premolar and the first molar.

Pressures were recorded with the subject sitting ' at rest ', whilst swallowing 2 ml. of water, and whilst speaking the phrase ' M one, M two, M three '. After a period of practice this exercise routine was repeated ten times and the mean value and standard deviation for each exercise were calculated. A tracing from a sample record chart shows the type of pressure pattern that was obtained (*Fig.* 1). Before beginning each exercise routine the subject held his lip and cheek clear of the sensors in order to give a base line reading.

Presented at the Research Meeting held on 9 May, 1968.

The pressure value for each exercise was taken as the maximum deviation from the base line that it produced. At the beginning and end of a recording session with each subject, both sensors were calibrated against an accurate mercury manometer and a calibration graph was drawn.

Individuals showed a fairly consistent pressure pattern for each exercise though there was considerable variation in the size of the pressures produced with each repetition. Different individuals produced markedly different pressure patterns.

The extreme range of buccal pressure recorded in the upper first molar region, together with the mean pressure for all 30 subjects is shown for each exercise in *Fig*. 2.

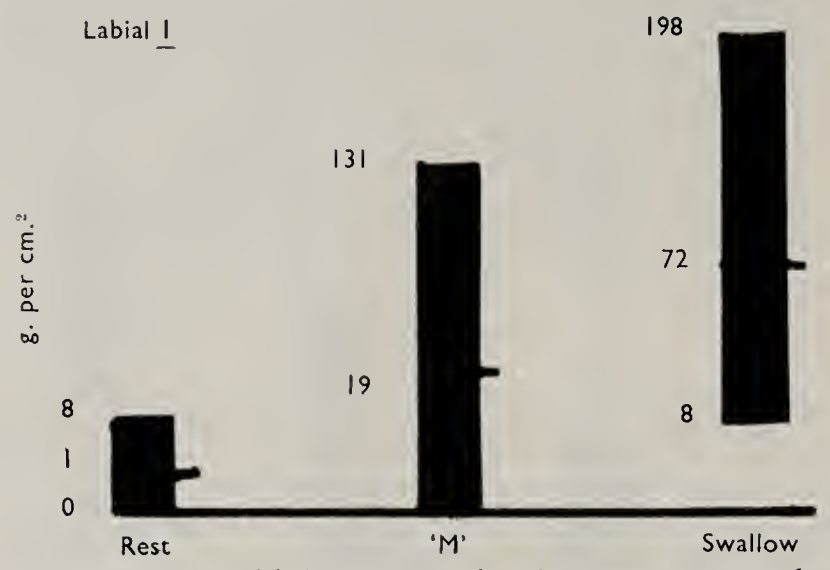

Fig. 3.—Labial pressure in the upper central incisor region in a group of 30 subjects. Column height shows the extreme range for each exercise whilst the horizontal bar marks the mean pressure for the group.

During ' rest ' most subjects showed some buccal pressure in the upper first molar region. One subject, however, who had a gross skeletal Class III malocclusion with a molar cross-bite never exhibited a buccal pressure during ' rest '.

The pressures recorded showed general agreement with those quoted by other authors. Buccal pressure during ' rest ' was identical with that quoted by Gould and Picton (1964) for subjects with normal occlusion. Buccal pressures during ' M ' and ' swallow ' lay between those found by Gould and Picton in the maxillary first molar and first premolar regions. As the sensor in the present study was placed in the interdental space between the first maxillary molar and the second premolar this agrees with the findings of the same authors that buccal pressures are higher near the modiolus.

The extreme range of pressure recorded in the upper central incisor region, together with the mean pressure for all 30 subjects, is shown for each exercise in *Fig*. 3. During ' rest ' no labial pressure was recorded in 11 out of 30 subjects and the mean pressure was very low. This agrees with the findings of Proffit, Kydd, Wilskie, and Taylor (1964) who reported no labial pressure during ' rest ' in 23 out of 25 subjects. Gould and Picton (1964), on the other hand, have reported a labial pressure during ' rest ' of 7 g. per cm.² During ' M ' and ' swallow ', labial pressures were similar to those reported by Gould and Picton.

Not only was there variation between the performance of different individuals, but the performance of one individual varied considerably on different occasions. Indeed, the difference between the same subject upon different occasions could be greater than the difference between two subjects.

This situation is illustrated in *Fig*. 4 where the performance of 1 subject upon six different occasions is superimposed upon the mean and

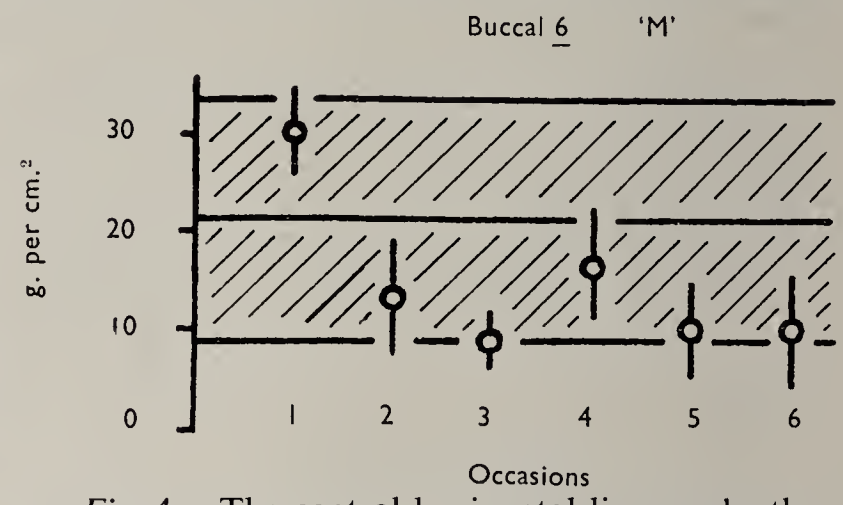

Fig. 4.—The central horizontal line marks the mean pressure and the shaded area the standard deviation for a group of 10 subjects of similar occlusion. Each circle and vertical bar marks the mean pressure and standard deviation for an individual member of the group, recorded upon six different occasions.

standard deviation for a group of 10 subjects of similar occlusion. It is seen that the performance of this one individual at different times spanned the whole pressure range for his occlusal group.

Six subjects recorded upon two separate occasions confirmed that this variation was not a systematic one as the value for one exercise sometimes increased when that for another decreased. This suggested that the variation more probably arose from some change in subjective behaviour than from a change in the apparatus or sensor position. Great care had been taken in positioning the sensor each time and it seemed unlikely that the very slight change in position that might have occurred could have caused such a large variation between results.

This possibility, however, was tested by a laboratory experiment in which a sensor was removed and replaced five times. When this was done the pressure variation due to removal and replacement of the sensor was found to be barely detectable.

Since the variation between occasions seemed to be a real phenomenon it was considered that pressure recordings from one individual upon a single occasion could not be regarded as typical

of that individual. No attempt was, therefore, made to compare individuals, but instead subjects were divided, on the basis of incisor overjet, into three groups corresponding to Angle's Class I, Class II, division 1, and Class III malocclusion. Overjet was defined as the horizontal distance between the labial surfaces of the upper and lower central incisors when the teeth were in centric occlusion. Subjects with an overjet of 2–4 mm. formed the Class I group. Subjects with an overjet of 4·5 mm. or more formed the Class II, division 1 group, whilst subjects with an overjet of 1 mm. or less formed the Class III group. There were ten subjects in each group and the mean pressures in g. per cm.^{2} and the standard deviation for each exercise are compared using Student's ' *t* ' test in *Table I.* In the maxillary first molar region all groups exhibited some buccal pressure during ' rest '. Although this pressure was small, there was a statistically highly significant difference between the three groups. For the ' swallow ' exercise there was no difference between groups, whilst for the ' M ' exercise, Class I and Class II, division 1 were similar, with Class III exhibiting a lower pressure.

In the upper central incisor region, labial pressure during the ' M ' exercise showed a statistically highly significant difference between the three groups. During the ' swallow ' exercise the Class I group produced the lowest pressure, significantly lower than that produced by the Class II, division 1, group but not significantly different from that produced by the Class III group.

Where a labial ' resting ' pressure was recorded at all, it was very small and although mean pressure for the Class I group was lower than that for the other two groups it is felt that this result, so close to the limit of resolution of the apparatus, must be taken with some reservation.

To summarize, there was little difference between the groups in the ' swallow ' exercise both buccally and labially. In the ' M ' exercise and in buccal ' rest ', the Class III group produced the lowest pressures.

In members of the Class III group, the attachment of the lower lip and cheek to the mandible would lie further outwards radially in the horizontal plane than in Class I or Class II, division 1, subjects. In this situation, it might be expected that pressure upon the outside of the upper dental arch would tend to be reduced as the vestibular tissues would be pulled outwards towards their mandibular attachment when the lips were closed.

This hypothesis would account for the differences that have been found between groups during the ' M ' exercise. In the buccal position during ' rest ', however, the Class I group exhibited, surprisingly, a higher pressure than the Class II, division 1, group. Abrams (1963) has demonstrated the presence of bands of pressure concentration within the buccinator sheet. Differences in buccal pressure during ' rest ' could be explained if the relation of such

Table I.—Comparison of Labial and Buccal Pressures in 3 Groups of 10 Subjects*

Group	Incisor Relationship	Buccal 56			Labial 1		
		' M '	Rest	Swallow	' M '	Rest	Swallow
A	Normal Overjet	21·1±12·5	7·2±4·3	46·4±30·6	18·2±13·5	0·8±1·3	63·8±32·9
B	Increased Overjet	20·9±12·7	5·4±2·9	42·0±25·2	27·2±20·1	1·4±2·1	82·0±34·5
C	Reduced Overjet	11·5±9·2	3·0±2·4	45·0±37·8	10·3±8·7	1·4±2·1	70·5±55·8

't' Test of Level of Significant Difference between Groups							
	A/B	Obviously Similar	Different $P=0·001$	Obviously Similar	Different $P=0·001$	Different $P=0·02$	Different $P=0·001$
	B/C	Different $P=0·001$	Different $P=0·001$	Obviously Similar	Different $P=0·001$	Obviously Similar	Not Significant
	A/C	Different $P=0·001$	Different $P=0·001$	Obviously Similar	Different $P=0·001$	Different $P=0·02$	Not Significant

* Figures show means and standard deviations in g. per sq. cm. for ten repetitions of each exercise by each subject. $N=100$.

pressure bands to the molar teeth were different in Class I and Class II, division 1, subjects. The similarity of the three groups in the ' swallow ' exercise, where the heaviest pressures were produced, suggests that peak buccal and labial forces during swallowing have no significance in relation to arch form. The difference between groups discovered in the ' M ' exercise are probably secondary to the skeletal and soft-tissue morphology perhaps by the mechanism already suggested. Marx (1965), using electromyography of the circumoral muscles, found increased overjet to be associated with increased muscle activity. One of his conclusions was that in ' resting posture ' mentalis and lip activity is secondary to incisor position. In this study, increased labial pressure was found associated with increased overjet during the ' M ' exercise and in ' resting posture '. This adds support to the contention that labial pressure is secondary to incisor position.

The variation in subject performance on different occasions is felt to be important as it appears large enough to invalidate the comparison of individuals upon the basis of a single recording. This variation with time has also been reported by Gould and Picton (1962) and by Lear, Catz, Grossman, Flanagan, and Moorrees (1965) in their measurements of soft-tissue pressure. Other physiological measurements in which a subject is required to repeat a specified action, exhibit similar variation with time. Wertz (1968) in making measurements of nasal air-flow at rest, postulated alterations in the state of patient anxiety as a reason for the range of nasal air-flow recorded. Anderson (1954) when studying masticatory forces noted day-to-day variation in both the number of chews and the total load per sequence when individuals chewed and swallowed a ' standard biscuit '. He commented ' it is highly probable that even under completely normal conditions of chewing without any experimental interference, the number of chews and the force applied are subject to wide variation with the same material. Many factors, psychological and physiological, must contribute to this variation.'

Even where the question of conscious control does not arise the biomechanical properties of soft tissues seem subject to great variation. Investigations by Kenedi (1968) of the biomechanical properties of human skin *in vivo* have shown that values for skin elasticity, at the same site, in the same subject may vary by 100 per cent over a short period. This variation is thought to arise from changes in blood-flow and extravascular fluid volume.

The factors which affect skin elasticity must also affect the oral soft tissues and the forces which they exert upon teeth. Where these forces are increased by muscle activity further variation will arise from the changing levels of cortical control over muscle action. On top of this, quite apart from the intrusion of recording apparatus, the voluntary repetition of experimental exercises must raise to the level of consciousness muscle activity that would normally occur subconsciously. Thus, where soft-tissue forces are to be measured, a high degree of variation with time must be expected. Where an individual is compared at different times or where different subjects are compared on the basis of a single recording, any but gross differences are likely to be hidden by the high level of individual variation.

For this reason it is considered that the measurement of soft-tissue pressures can have little value as a clinical diagnostic method for individual patients. As a research tool, however, where groups of similar patients can be compared, it is a useful means to investigate factors affecting arch form.

Acknowledgements

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THE PRIMACY OF FUNCTIONAL MATRICES IN OROFACIAL GROWTH

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INTRODUCTION

I AM cognizant of the honour afforded me in being asked to deliver the Northcroft Memorial Lecture at this Jubilee Meeting of the British Society for the Study of Orthodontics. That Anglo-American orthodontics share a common tap-root is documented by the fact that among those joining with Mr. Northcroft in the foundation of this Society were some who had studied in America with Angle. The subsequent development of what I may call cis- and transatlantic orthodontics has been characterized by many divergent trends. Despite our seeming differences, a common denominator has been our abiding interest in the biology of orthodontics. It is, perhaps, appropriate that this occasion provides an opportunity for the presentation of some of the newer thoughts current in my country, if for no other reason than it may dispel the image of a group of colonial wire-benders interested only in the mechanics of intra-oral carpentry.

The intelligent practice of orthodontics has two basic requirements. The first is to master the biomechanical techniques for regulating tooth position. The second is to possess an intimate knowledge of the structure and growth of the head. In the past the interaction between these two sets of information was considered to be only nominal, despite the recognition that successful therapy was related to intervention in the facial growth process at appropriate times and within a limited range of force vectors. With the recent increasing awareness of the biological bases for therapy, the objective validity of the craniological concepts of the practitioner became more important. It is unfortunately true that many classic theories of cranial structure, as well as derivative conjectures about facial growth processes, are incorrect. To the extent that orthodontic diagnosis, therapy, and prognosis is predicated upon these obsolete ideas, they too are incorrect. Recently, several new approaches to craniology have appeared. One of these is the method of Functional Cranial Analysis. It is my purpose here to describe this method briefly, and then to develop the clinical implications of a derivative concept: the primary morphogenetic role of the functional matrix.

FUNCTIONAL CRANIAL ANALYSIS

The head is a region of the body within which a number of relatively independent *functions* are carried out; respiration, olfaction, vision, hearing, balance, chewing, digestion, swallowing, speech, and neural integration. Each of these functions is carried out by a separate *functional cranial component*. Each component consists of all of the tissues, organs, spaces, and skeletal parts necessary to carry out a given function completely. The tissues, organs, and functioning spaces, taken as a whole, comprise the *functional matrix*; while the skeletal tissues (osseous, as well as cartilaginous) related to this specific functional matrix are the *skeletal unit*.

Aside from its role in mineral homeostasis, skeletal tissues have only a biomechanical role in the body. Specifically they serve to protect and/or to support their related functional matrices. All skeletal tissues originate, grow, and function completely embedded within their several matrices. It is now reasonably certain that there is no *direct* genetic influence on the size, shape, or position of skeletal tissues, although there is undoubted genetic control of the initiation of ossification. There are no genes for bone (Grüneberg, 1963). Indeed, the available data strongly suggest that all genetic skeletogenic activity is primarily upon the embryonic functional matrices, and only secondarily, through

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biomechanical processes, upon the skeletal tissues themselves. This statement correlates well with the available experimental and clinical data which, in summary, show that all changes in the size, shape, and spatial position of all skeletal units, including their very maintenance in being, are due to the operational activity of their related

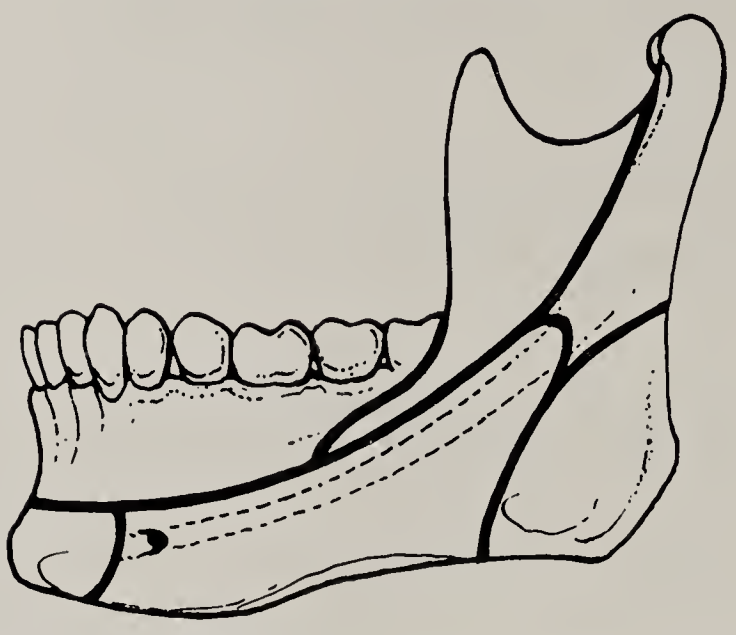

Fig. 1.—A schematic representation of some of the mandibular skeletal units. It is emphasized that the sharp division between these relatively independent units most probably does not exist, but is shown in this manner for didactic purposes only (*see also Fig.* 4).

functional matrices. Briefly, bone structure and bone growth reflect extrinsic, environmental factors rather than intrinsic, genetic ones. The data supporting these conclusions have been published elsewhere extensively (Moss, 1954, 1955, 1957a, 1958a, b, c, 1959a, b, 1960a, b, 1961a, b, 1962, 1964, 1965, 1968; Moss and Greenberg, 1967; Moss, Ju, and Crikelair, 1963; Moss and Rankow, 1968; Moss and Young, 1960).

THE SKELETAL UNIT

Prior to our exposition of the functional matrix, it is well to discuss certain properties of the skeletal unit. The named bones of formal osteology are not, in any way, identical with skeletal units. As such, there is no biological reality to the terms maxilla or mandible. Each of these has been shown to be composed of a number of *contiguous* skeletal units (Moss, 1960b; Moss and Greenberg, 1967).

When any ' bone ' of formal osteology is composed of several contiguous skeletal units, we term these *micro*-units. For example, the mandible has within it alveolar, angular, condylar, gonial, mental, coronoid, and basal microskeletal units, among others (*Fig.* 1). Similarly, the maxilla includes nasal, orbital, pneumatic, palatal (both oral and nasal), and basal contiguous microskeletal units (*Fig.* 2). Some microskeletal units are *adjacent* rather than contiguous, i.e., two skeletal units which serve the same functional matrix but are separated in space. An example is the lateral surface of the mandibular angular process and a portion of the zygomatic arch, both of which are related to the functional demands of the masseter muscle. In those cases in which the skeletal unit is composed of portions of several adjacent ' bones ', in the formal osteological sense, we deal with *macro*-skeletal units. The entire endocranial surface of the calvaria is one such macro-unit, serving to protect and support the enclosed neural mass,

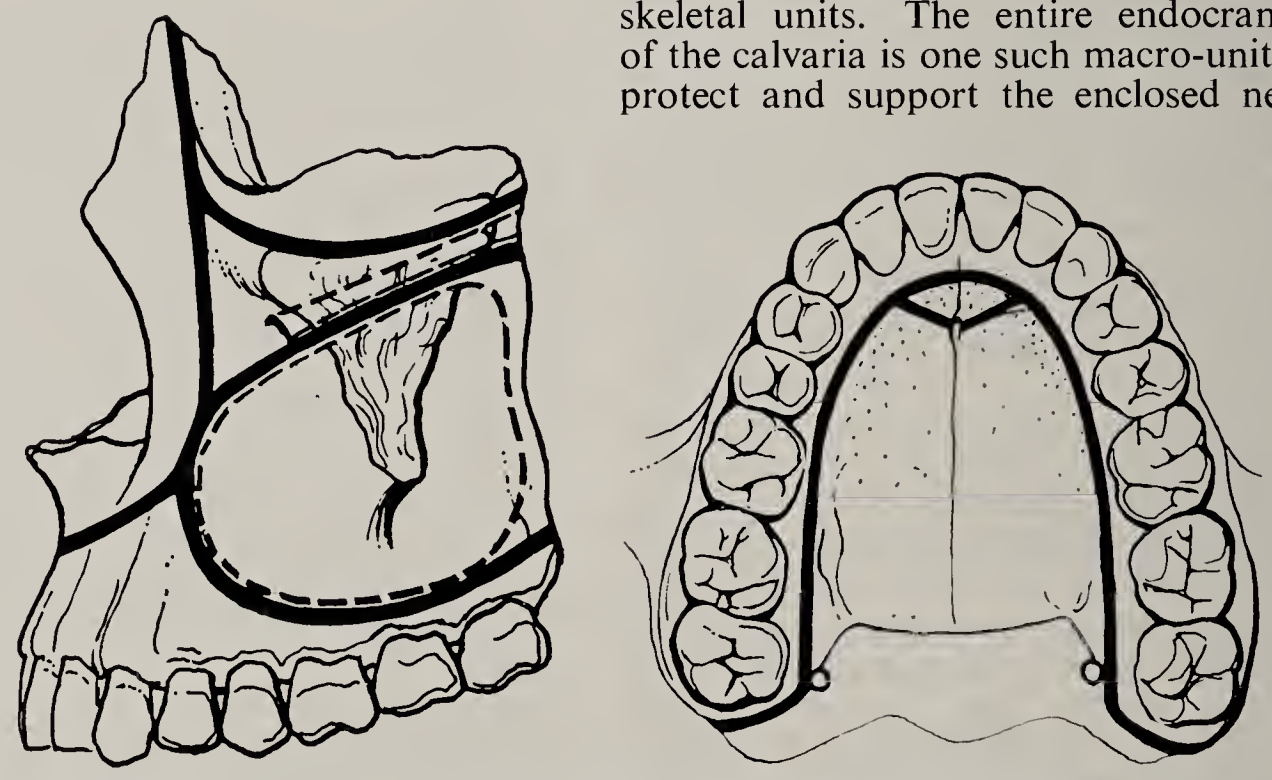

Fig. 2.—The several maxillary skeletal units are illustrated in the same manner as in *Fig.* 1, with the same provisions.

while the orbital surfaces of all the bones comprising the bony orbit form another such macro-unit subserving the functional demands of the orbital mass.

In *Fig.* 1 the contiguous mandibular microskeletal units are shown separated by a series of lines. This depiction is used for didactic purposes only. In reality there may be a considerable degree of overlap in the morphological expressivity of contiguous microskeletal units. We

stated above that the several functional cranial components are *relatively* independent of each other, thus indicating that there may be a considerable degree of interrelationship (overlap) between such units. While we will discuss this topic extensively elsewhere, it is useful to outline here some of the implicit theoretical aspects of this statement. The morphological expressivity of any skeletal unit can be depicted graphically in the form of a distribution curve. Some units have a ' normal ' (Gaussian) distribution (*Fig.* 3A) implying ' average ' expressivity, other units have a very discrete expressivity (as a styloid process) (*Fig.* 3B), while still other skeletal units are morphologically indistinct, or diffuse (as in the calvaria) (*Fig.* 3C). Limiting our discussion to the normal distribution, let us consider the possible degree of interrelationship between two contiguous microskeletal units, such as the mandibular angular process which is a response to the functional demands of both the masseter and medial pterygoid muscles. Our basic postulate is that the size, shape, position, and maintenance in being of each skeletal unit is a response to the demands for protection and/or support of its specifically related functional matrix. If two contiguous functional matrices are totally independent of each other, their two skeletal units would be similarly independent in their morphological expression (*Fig.* 4A). However, when two functional matrices partially participate together in the evocation of their skeletal units, then the expressivity of these two units will overlap each other. In this case there will be an area of skeletal unit tissue which simultaneously is a response to the demands of both functional matrices. A symmetrical instance is shown in *Fig.* 4B. This is roughly the condition at the mandibular angular process (Avis, 1961).

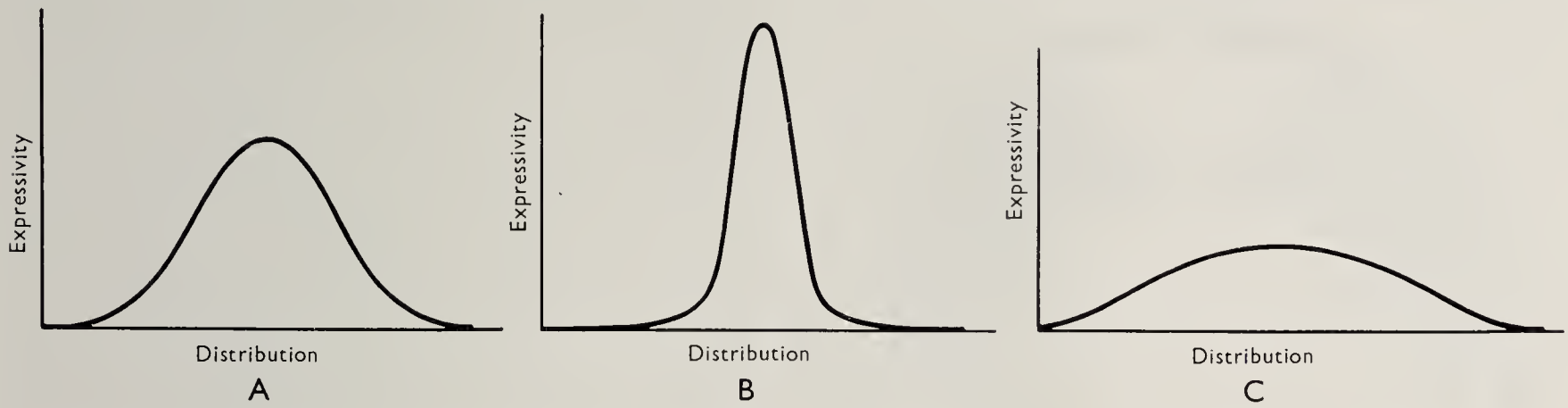

Fig. 3.—These three figures attempt to represent possible modes of morphological expressivity of any cranial skeletal unit. If we assume that the mandibular angular process has a ' normal ' expressivity, this will be shown in the mesokurtic form of curve (A). A morphologically distinct unit, such as the styloid process, will have a leptokurtic distribution (B), while the diffuse expression of the calvarial vault will have a platykurtic distribution (C).

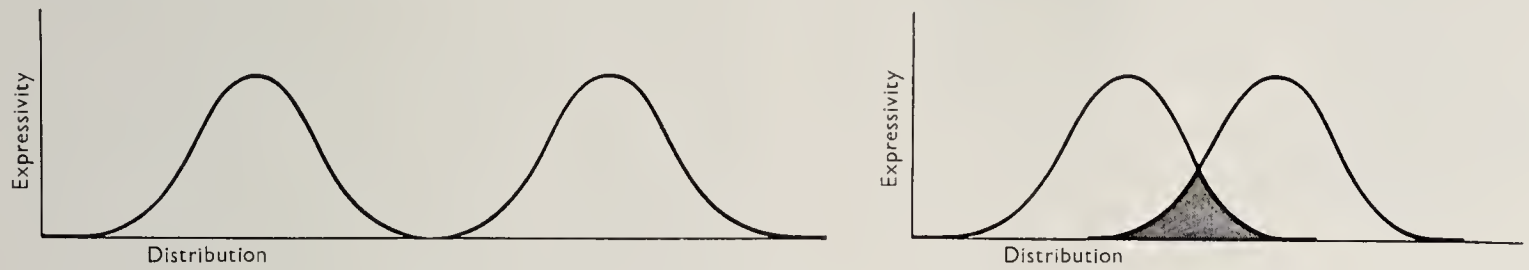

Fig. 4.—In reality few contiguous skeletal units probably are totally independent of each other. If they were, two normal curves (A) would express their non-overlapping expressivity of form. The mandibular angular process is composed of two skeletal units, an outer surface responding to the masseter muscle and an inner surface responding to the medial pterygoid muscle. Hence the morphological expressivity of this angle probably results from an interaction between both functional matrices and the form of the contiguous skeletal units overlap (B).

THE FUNCTIONAL MATRIX

Functional matrices provide the extrinsic (environmental) influences which are morphogenetically primary for the form, growth, position, and maintenance in being of all skeletal units. A more complete understanding of the processes by which functional matrices influence skeletal units is obtained by a redefinition of the word growth. Earlier we defined growth as a change in any morphological parameter which is capable of measurement. Basically, there are two types of skeletal unit (bone) growth: (1) changes in form (i.e., size and shape); and (2) changes in spatial position. For example, the size and shape of the angular and coronoid mandibular processes are secondary, and compensatory, to primary changes

in the functional demands of the masseter, medial pterygoid, and temporalis muscles respectively. However, the form of these skeletal units *can* alter without concurrent change of mandibular position in space. This is clearly seen, in adults, in masseteric hypertrophy as well as in post-traumatic or postinfective paralysis of the temporalis muscle. In one case the angular process

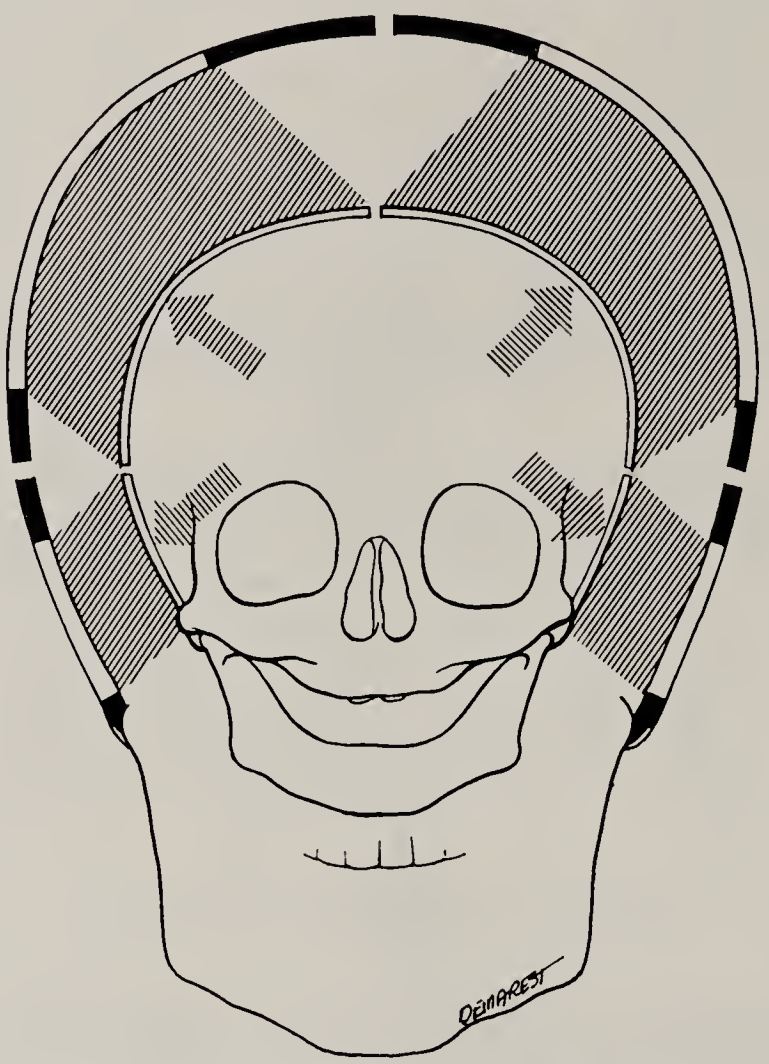

Fig. 5.—The calvarial bones are embedded within a neurocranial capsule. This capsule expands in response to a volumetric increase of the capsular neural matrix. As a result, the embedded bones are passively carried outwards, by the processes of translative growth Periosteal, transformative growth processes now add bone at the sutural margins, but these areal increments are secondary and compensatory, rather than primary, in calvarial expansion.

increases its lateral flare, while in the latter the coronoid process decreases in size and alters its shape without a concurrent alteration of the spatial position of the mandibular complex. It is true, nevertheless, that in sub-adults, changes in form usually occur simultaneously with spatial relocation of the mandible. This bodily movement of the lower jaw in space demonstrates the second type of growth, which can be independent of the first type.

Before describing these two growth processes in detail, let us define the corresponding types of functional matrices with greater precision. Dealing with osseous skeletal units, we term them *periosteal* and *capsular*. Periosteal functional matrices act directly and actively upon their related skeletal units. Alteration in their functional demands produces a secondary, compensatory *transformation* of the size and/or shape of their skeletal units. Such transformations are brought about by the interrelated processes of deposition and resorption of bone. Excellent examples of such periosteal matrices are the masseter, temporalis, and pterygoid muscles. The *capsular* functional matrices differ completely in their action. They act indirectly and passively on their related skeletal units, producing a secondary, compensatory *translation* in space. These alterations in spatial position of skeletal units are brought about by the expansion of the orofacial capsule within which the facial bones arise, grow, and are maintained. The facial skeletal units are passively and obligatorily moved in space as their enveloping capsule is expanded. Translative growth is not brought about by deposition and resorption of bone tissue. The oral, nasal, and pharyngeal cavities, considered as *functioning spaces*, are examples of such matrices.

While translative growth may occur in the absence of either resorption or deposition of bone, translative and transformative growth usually occur simultaneously in sub-adults. In the past, the failure to differentiate between these two, diametrically opposed, types of growth has led to the critical misinterpretation that the activity of periosteal matrices also served as the primary source of translative growth. The substantial differences between the two types of functional matrices has been emphasized also by Fränkel (1967) who referred to ' developmental-mechanical ' and ' functional-mechanical ' influences on facial growth, terms which I regard as substantially equivalent to capsular and periosteal matrices respectively. The operational differentiation between the processes of skeletal unit growth which occur secondary to the functional demands of these two types of matrices clarifies the matter.

TRANSLATIVE GROWTH

The developing, embryonic neural mass is originally surrounded by a non-skeletal neurocranial capsule. Similarly, the embryonic oral, nasal, and pharyngeal cavities are effectively surrounded by an orofacial capsule. Within their respective capsules the neurocranial and splanchnocranial skeletal unit tissues arise. With regard to bony tissues, the presumptive skeletal units first form as primary ossification centres (whose sites may also be biomechanically determined, *see* Graumann, 1951). These centres rapidly expand until each presumptive ' bone ' attains its definitive position relative to other, adjacent ' bones ' (*see* Moss, 1954; Moss, Noback, and Robertson, 1956, for details). In the neurocranium the primary growth force is derived from the volumetric expansion of the enclosed neural

mass (brain, meninges, cerebrospinal fluid). Vectorially directed by the structure of the dura mater, the neurocranial capsule expands secondarily in response to this increase in functional matrix volume. Accordingly, the developing calvarial bones are *passively* carried upwards and outwards *within* their enclosing capsule (*Fig.* 5). It is generally accepted now (using the nomenclature of Koski) that neurocranial sutures are not primary growth *centres* for calvarial expansion, but rather are growth *loci*—the sites where secondary, compensatory incremental periosteal growth occurs, serving to keep adjacent bones approximated, and mechanically useful sutural areas in being (*see* Moss, 1954, 1955, 1957b, 1958b, c, 1959a, b, 1960a, 1961a, for supportive data). There is no primary expansive force generated by interstitial growth of any sutural connective tissues. The periosteal growth observed at sutural areas is *not* the primary source of the upwards and outwards translation of the calvarial bones. It is true, that concurrent with such translative growth, direct periosteal transformative growth occurs also. Accordingly, there is alteration of curvature of the calvarial 'bones', differentiation of inner and outer cortical tables, their thickening, increase in both pneumatic and diploic spaces, as well as the areal extension referred to above. Increasingly the calvarial skeletal units show the morphological characteristics of their independent response to ectocranial, endocranial, pneumatic, and diploic *periosteal* matrices. Indeed these periosteal matrices continue to elicit direct, secondary, skeletal unit changes at all ages, long past the time when capsular matrices have ceased their expansive, translative growth. So that while definitive neurocranial volume is attained by the third or fourth year, senile white females, for example, show hyperostosis frontalis interna of the inner calvarial plate following idiopathic shrinkage of the frontal cerebral lobes.

Facial skeletal growth processes include a homologous, but more prolonged, phase of translative growth. The capsular functional matrix whose morphogenetically primary volumetric increase causes the orofacial capsule to expand is the common oronasopharyngeal cavity (*Fig.* 6). This point requires clarification. In my earlier writings I referred to those cavities as biological empty spaces. Thanks to a colleague, Dr. Letty Salentijn of the University of Utrecht (who suggested this more meaningful phrase), I now call these the *functioning spaces* of the face. Let us define this concept more clearly. The oral cavity is not simply a space adventitiously left over after the bones, muscles, glands, vessels, and cartilages of the region finish their growth. An operational consideration of either the digestive or of the respiratory system demonstrates that the *use* of these systems, and indeed the very life of the individual, depends upon the patency of these passageways. This viewpoint in no way suggests pneumatic forces as an explanation. Our conception of the operative mechanism is totally functional.

These functioning spaces are genetically determined and functionally maintained. Specifically, I believe that the functioning spaces first

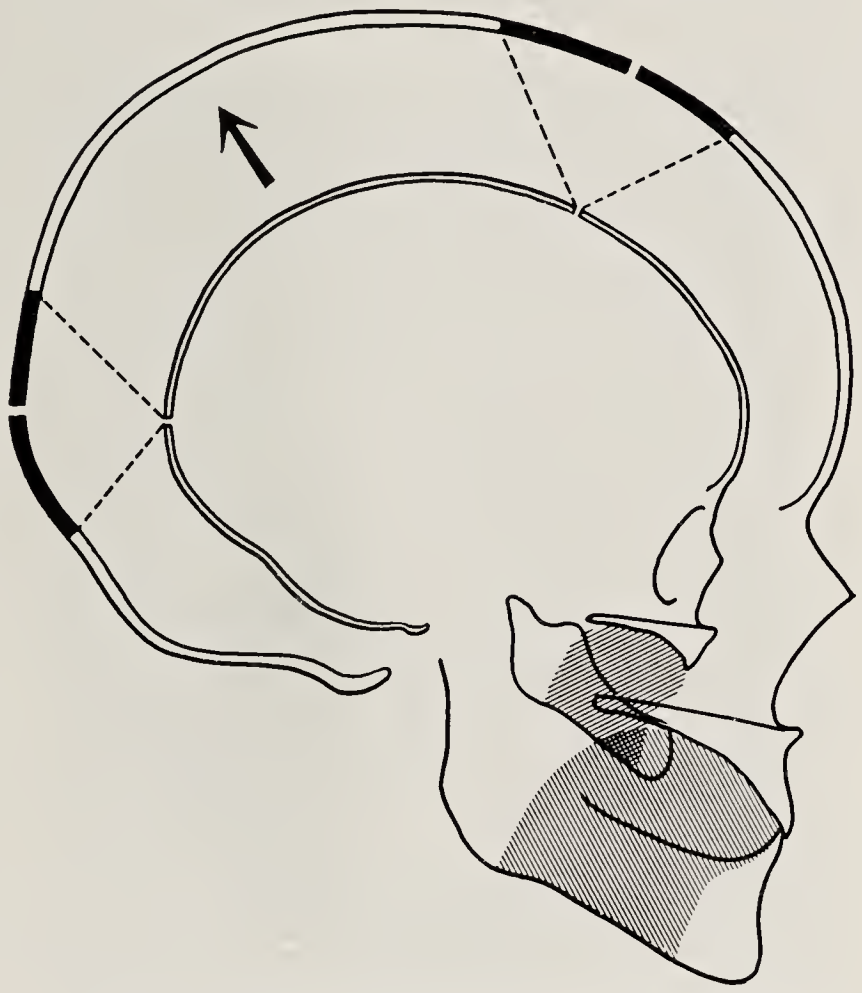

Fig. 6.—The volumetric increase in oral cavity matrix volume is depicted, together with that of the neural mass, in an attempt to show the basic homology of these translative growth processes. The orofacial capsule expands in a secondary, compensatory manner to the morphogenetically primary expansion of the enclosed oronasopharyngeal functioning spaces (*see also Fig.* 7).

are formed in a process of enclosure by the genetically determined growth of the primordial capsular tissues (*entwicklungsmechanik*). Once formed these spaces are maintained by their own functioning (*funktionellmechanik*). In the first phase, even though the genetic activity is mediated by the capsular tissues, the pressure of selective evolutionary processes has been to establish an adequate functioning space, *per se*. The growth of the capsular tissues, subsequent to the initial embryonic enclosure now depends upon the primary morphogenetic influence of the spaces so enclosed. An analogy may help. We may imagine a rectangular sheet of paper of finite dimensions. If we form a cylinder with this sheet, the enclosed volume is predetermined by the dimensions of the paper. However, it is possible also to conceive of a functionally adaptive spatial volume, which requires a surrounding capsule for its protection and support. If our hypothetical

paper represents this capsule, we now may think not of a single sheet, but rather of a roll of paper from which as much material as is necessary may be taken to encompass the functioning space. That the volume of these spaces is of great adaptational significance, in an evolutionary sense, seems obvious. It is admitted that at present we lack complete experimental proof of

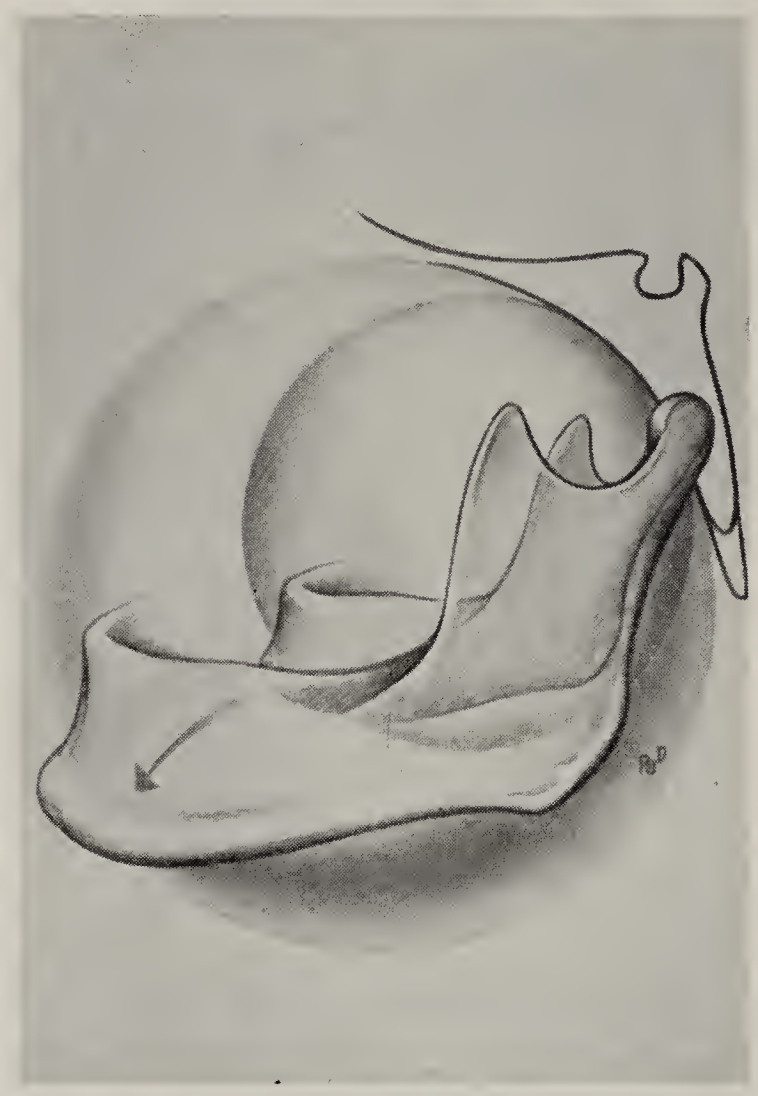

Fig. 7.—The oronasopharyngeal cavity is a functional space matrix whose primary volumetric growth causes the surrounding orofacial capsule to expand within it. This produces a translative growth of the embedded mandible, while transformative growth of the several mandibular skeletal units occurs simultaneously. The net effect of these two processes is illustrated.

for the human nasal cavity, where absence of respiratory function, due to congenital bilateral choanal atresia, is accompanied by a marked underdevelopment of this functional space (Cracovaner and Goodman, 1956). With respect to the oral and pharyngeal cavities, our concept receives significant support from the work of Bosma, who correctly speaks of this functioning space as an ' airway maintenance mechanism ' (Bosma, 1963a, b; *see also* Bosma, 1967). Bosma agrees that there is a ' very high priority . . . assigned ' to the space, which I interpret as indicating that there is a genetic and adaptational basis for this translative matrix. The morphogenetic primacy of a functioning oral cavity is indicated as follows: ' Postnatal development of the tongue is also integrally related to the acquisition of an *open masticatory cavity*. Teleologically speaking, it is this expansion of *available performance area* which makes the

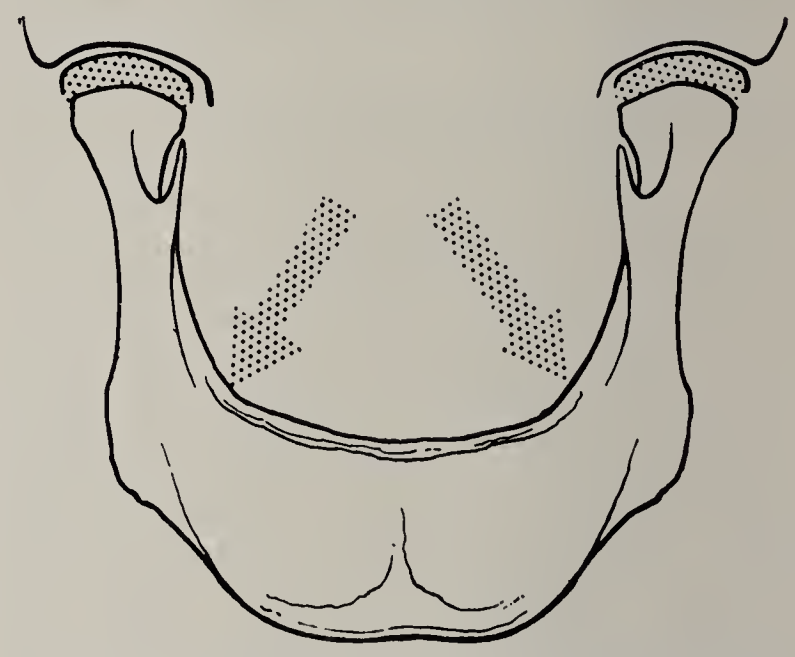

Fig. 8.—Translative growth of the mandible within the orofacial capsule tends to cause distraction of the condylar process. The undoubted increments of growth observed here are secondary, compensatory, and mechanically obligatory in nature. Such condylar growth emphatically is not the primary source of growth which moves the mandible in space.

the primacy of the morphogenetic role of functioning spaces in the passive and indirect translative growth of splanchnocranial skeletal units within their enclosing orofacial capsule. Strongly suggestive data, however, do exist. The development of the oesophageal lumen (functioning space) is functionally determined and maintained. Obliteration and stenosis of the foetal oesophagus in man occurs if insufficient amniotic fluid (and mucus) is available for prenatal swallowing (Bok, 1965). Barcsa and Mohácsi (1962) demonstrate that ' the onset of deglutition has a profound formative effect on the further development of the oesophagus ' in the newborn chick, and indeed that crop-fed chicks showed marked loss of volumetric (translative) growth. Similar sorts of data are available anteriorward elongation and greater mobility of the tongue feasible and possible' (Bosma, 1963a; italics mine).

The hypothesis of passive translative facial skeletal unit growth is strongly supported by both experimental and clinical data. Let us consider mandibular growth first. The downward and forward relocation of the contiguous mandibular skeletal units as a whole occurs as a response to the primary volumetric increase of the oral, nasal, and pharyngeal cavities. The orofacial capsule expands and carries the completely embedded mandible in the direction of these growth vectors (*Fig.* 7). An identical passive translative movement occurs also in patients congenitally missing all normal ramal skeletal units bilaterally. The mandibular condylar

cartilages emphatically are not primary growth centres. The interstitial, expansive growth of this tissue does not generate the primary force which, by redirection against the mandibular fossa, forces the mandible down and forward. The situation is quite the contrary. Translative growth of the mandible within the expanding orofacial capsule carries the head of the condyle away from the articular eminence; a distractive movement as it were. The undoubted increments of growth observed in the condylar articular cartilage (which is in no way homologous to an epiphyseal growth plate) is a secondary, compensatory event. Simply put, the condylar cartilages grow upwards to compensate precisely for the amount of passive translation downward (*Fig.* 8). Bilateral, total condylectomy, in both laboratory animals and in man, is consistently followed by normal translative growth of the now non-condylar mandible (Moss, 1959b, 1960b; Moss and Rankow, 1968).

The thesis of cartilaginous primacy in translative growth has many able advocates. Scott (1967), in particular, has consistently implicated nasal septal cartilages as the primary growth centre for relocation of the skeletal units of the upper jaw, as indeed have Sarnat (1963) and Sarnat and Wexler (1966). However, recent experiments show that total removal of this septal tissue in young rats is not followed by a loss of normal dimension or altered spatial growth of the mid-facial skeleton, a conclusion supported by human data (Moss, Bromberg, Song, and Eisenman, 1968). The arrhinencephalic term foetus (with no contiguous nasal cartilaginous tissue of any sort) has a maxilla of normal size, shape, and position (*see* Moss and others, 1968). It is obvious now that the growth of condylar, nasal, and presumably basal cranial, cartilages are secondary, compensatory, and mechanically obligatory events, in all ways homologous with the compensatory growth observed at the sutural margins of all intramembranous cranial bones. Translative growth at both sites is secondary response to the morphogenetically primary growth of capsular matrices.

TRANSFORMATIVE GROWTH

In sub-adults, periosteal matrices are active simultaneously during translative growth. The recent publications of Enlow's laboratory are excellent examples of the newer data available on this type of growth (Enlow, 1963, 1966a, b; Enlow and Harris, 1964; Enlow and Hunter, 1966). Showing, as they do, the sites of osseous deposition and resorption, they easily lend themselves to misinterpretation as indicating the process of translative, rather than of periosteal growth. In essence, Enlow's data illustrate two points: (1) how and where the cranial 'bones' compensate for their translative growth; and (2) how and where cranial skeletal units respond to their periosteal matrices. We must carefully distinguish again between these two events. An over-simple analogy may help. Let us consider the situation of a man running up an escalator which is moving downward. If his upward speed is precisely that of the escalator, he remains in the same spatial position. This type of transformative growth is a compensatory response of periosteal matrices to translation in space. The vertical eruption of the dentition (a functional matrix), and the compensatory increase in alveolar bone height (its skeletal unit), is an excellent example. Tooth eruption is a response to an increase in the vertical height of the oral cavity, not a cause of it. In this category we place the compensatory vertical growth of the mandibular condyle, and of the backward growth of the other contiguous ramal skeletal units. These skeletal units grow in response to their periosteal matrices so that they may remain in the same relative spatial position. Manson (1966), in his study of mandibular growth of laboratory animals, correctly assesses such growth changes as secondary responses to functional matrices.

Periosteal matrices can alter their functional demands at any spatial position, causing their skeletal units to show direct, compensatory transformative growth changes in form. We have recently illustrated this in a study of the normal changes in direction of flaring of human mandibular angular process with age (Moss and Simon, 1968). Functional hypertrophy, or atrophy, of any of the muscles of mastication demonstrate this type of skeletal unit response. Similar analyses can be made of the comparative osteology of the mandible (Moss, 1968).

A final analogy may help. Consider an elevator moving within a shaft. A number of boxes are on the floor of the car. Motion of the elevator is translative motion. Wherever the elevator car moves, the enclosed boxes are passively carried. At any position of the car in the shaft, it is possible to rearrange the enclosed boxes, e.g., to build a pile of them. Such stacking of the boxes is a rough analogy of transformation. Both translation and transformation may occur either simultaneously or consecutively, but they are independent of each other. To put it concisely, for many years students of craniofacial growth have been observing the stacking of boxes and confusing this with motion of the car in the shaft.

THERAPEUTIC IMPLICATIONS

Orthodontic therapy may be accomplished in two ways: (1) by the alteration of tooth position alone; or (2) by the alteration of the spatial position of the jaws. In the first instance we deal with treatment of one functional matrix alone, the teeth. In the second instance (properly termed orofacial orthopaedics) we treat other functional

cranial components of the facial region. With regard to the first type of therapy, requiring tooth-borne appliances of whatever design and mechanics, functional cranial analysis offers only one concept. Treatment of one periosteal matrix (the teeth) affects only one skeletal unit (alveolar bone). Changes in either the form or position of any other functional cranial component will not occur. With respect to orofacial orthopaedics, the method of functional cranial analysis has considerable significance. It is possible to alter the spatial position of cranial skeletal units. This may be accomplished surgically, as in mandibular resection or maxillary repositioning. It is also possible to treat orofacial matrices with the sure expectation that the related skeletal units will respond. I do not speak of a naïve myotherapy, which can at best alter only the specific areas of muscle attachment. Nor do I consider that tooth position in any way represents a dynamic balance between lingual and buccolabial muscle force vectors, a point beyond our present topic. But it is possible to simulate orofacial matrices prosthetically. Bone is stupid; it can be fooled. The calvaria cannot distinguish between brain tissue and cerebrospinal fluid in hydranencephaly; neither can an enucleated or exenterated orbit distinguish between the increase of a normal orbital mass and a series of intra-orbital prostheses of increasing volume implanted by the ophthalmologist, in his successful attempt to cause an operated infantile orbit to grow to normal dimensions. Similarly, it is possible to widen permanently the mid-palatal suture by an appliance placed upon the appropriate skeletal units. The success gained in the prosthetic repositioning of the maxillary segments of the infant with complete alveolar and palatal cleft is another example of simulation of the oral functioning space matrices.

The normal volumetric expansion of the oronasopharyngeal functioning spaces may be represented vectorially as having both magnitude and direction. Magnitude of growth is seldom, if ever, disturbed; they frequently are maldirected. In the neural skull, premature cranial synostosis, or the application of a number of extracranial devices, are quite capable of altering growing neurocranial form (Moss, 1957b, 1958c, 1959a). Entirely homologous conditions exist in the facial skull. Ankylosis of the temporomandibular joint in growing children prevents the passive lowering of the mandible in space, as a result an increasing deformation of mandibular shape and position occurs. The obvious therapy, in both uni- and bilateral cases, is bilateral condylectomy, the conversion of the mandible to a ' hyoid bone ', which has been demonstrated to be clinically useful (Moss and Rankow, 1968). Similarly to the neurocranium, an external apparatus is capable of redirecting the forces of the expanding oropharyngeal functioning spaces. Recent analysis of the effects of the Milwaukee brace on facial growth is a case in point. While we do not ever wish to produce such facial deformation, these data point to a new therapeutic approach. It is necessary to remember that there are two basic types of external deformative appliances: active and passive. The former literally exert a force upon the skeletal unit. The apparatus used in mid-palatal suture widening is an example. The Milwaukee brace is an example of the second type. The apparatus does nothing actively. Simply by being immovable it resists the direction of the growth vector, and in so doing redirects it. When finally we are able to analyse the vectors of capsular matrix expansion, we shall then, theoretically, be in a position to redirect these same forces to the therapeutic benefit of our patients. Such knowledge is the goal of functional cranial analysis.

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DISCUSSION

Mr. J. D. Atherton said that, taking first the manner in which the cranial bone responded to the increase in size of the cranial contents, and linking this with the statement of Professor Moss that bones have no genes; Professor Moss has shown, diagrammatically, that the cranial bones increase in size as a passive response to the increase in size of the cranial contents. If this increase in size of the bones was purely passive, then one would anticipate that the bones would grow equally towards a mid-point. There were, however, few instances of sutures growing equally. If the bones did not have some independence, why was there a variation in the growth rate between the sutures?

With regard to sutures, he agreed that there was nothing special about the suture growth. It was merely that certain sutures were more active growth surfaces than other areas of the periosteum, but were not specially different histologically. However, removed as it were from their normal expansive force, or functional matrix, they did retain a high degree of growth. For example, in a paper reported to the Society it was shown that the growth of the palatal shelf in cleft palate dogs at birth was extremely active, although the surrounding mucoperiosteum simply passed around the shelf margin and did not link up with the shelf of the opposing side. Nor was this growth related to the functional space, as implied by Professor Moss, because sometimes the shelf could be pointing straight downwards and could still retain its growth. He asked for Professor Moss's comments on these points.

Another point was that, in hydrocephalus, the bone growth was not entirely passive. Because the brain expanded abnormally, there was an increase in the spaces between the bones.

The final point he wanted to make was with regard to Professor Moss's suggestion that the nasal septum did not push the maxilla downwards and forwards. Professor Moss showed that when the nasal septum was removed, the maxilla continued to grow downwards and forwards. This implied that the nasal septum did not push the maxilla downwards and forwards but it also did not necessarily show that its growth was being determined by the functional matrix. Could it not be equally well interpreted that the maxilla had its own growth potential to grow downwards and forwards?

Professor Moss pointed out that he had said that these forces were re-directed by the attachment of the dura mater, etc. One reason why these bones were not growing equally was because there was indeed a vectorial segmentation or re-direction. It was not simply a situation of equal expansion outwards in all directions. The forces were re-directed and the reason that growth outwards was not equal in all directions was primarily related to the simple fact that it was growing within a structural mechanical unity formed by the cranial base, the dura mater, and calvaria. He hoped Mr. Atherton had read his earlier works which were all confirmatory of the fact that if one bone of the calvarial bones were removed, it was possible to get an adjacent bone to grow into the space formerly occupied by the removed bone. The position of calvarial sutures was functionally determined, since calvarial bones happened to grow together.

He thought that he and Mr. Atherton might be able to reach agreement if Mr. Atherton would remember the distinction made in the paper, which was the difference between the developmental mechanical processes and the functional developmental processes. He was in complete agreement with Mr. Atherton that there was a genetic predetermination for the initiation of an ossification centre, although he felt that even here there might be a biomechanical factor operating. It had been shown by Traümann that intramembranous bone formation began in areas where there was no particular tension; neither shear, nor compression, nor torsion. The subsequent form of the bone was biomechanically determined.

The problem of hydrocephalus was a simple one. The child with hydrocephalus had such enormous expansion intercranially that the vessels within the neurocranial capsule were being compressed resulting in capsular ischaemia. The bone could not grow in areas of relative anoxia. To give another example, a case had been published in 1966 in the Scandinavian literature of a calvarial suture replanted to replace a fibular growth plate and the amount of growth occurring was six times what it would have been in situ. There was no limitation in theory to the amount of calvarial bone growth.

To return to the maxilla, he hoped he would be forgiven for being over-critical or over-pragmatic. He found it difficult to adopt an intermediate point of view about biological problems. He believed a thing was or was not. Either cartilage did push bone or it did not. That did not have to be discussed; all that had to be done was to experiment with it. He put it quite simply. He had done the suture work ten years ago, and other people had done it with mutually confirmatory results. If the sutures were taken out there was no inhibition of growth. It was therefore said that sutures were not growth centres. If the cartilages were taken out and there was no inhibition of growth, it was said that cartilages were not growth centres.

The President thanked Professor Moss for his stimulating lecture and regretted that time had curtailed what would otherwise be a lengthy discussion. He then presented Professor Moss with the Lecturer's Scroll.

A SPEECH PROBLEM

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CASE REPORT

A 15½-YEAR-OLD schoolgirl, Elizabeth A., was referred to me in July, 1967 by her dental practitioner on account of her speech.

On examination she was found to have essentially a normal occlusion marred only by the loss of 6| with some residual space being present. The incisor overbite was slightly reduced although complete and some imbrication of the labial segments was present. The lips were mildly incompetent but habitually held together (*Figs.* 1, 2). Her speech impediment was most unpleasant to the ear. I would describe it as a very forceful lateral sigmatism of almost clicking quality. I noticed the mandible was dropped and protruded asymmetrically to give a slightly greater opening on the left side anteriorly, when making the 'S' sound, whilst the tongue escaped posteriorly over the occlusal surfaces of the cheek teeth. On looking in the mouth immediately after 'S' sounds had been made, the lateral aspects of the tongue were seen to be slightly indented.

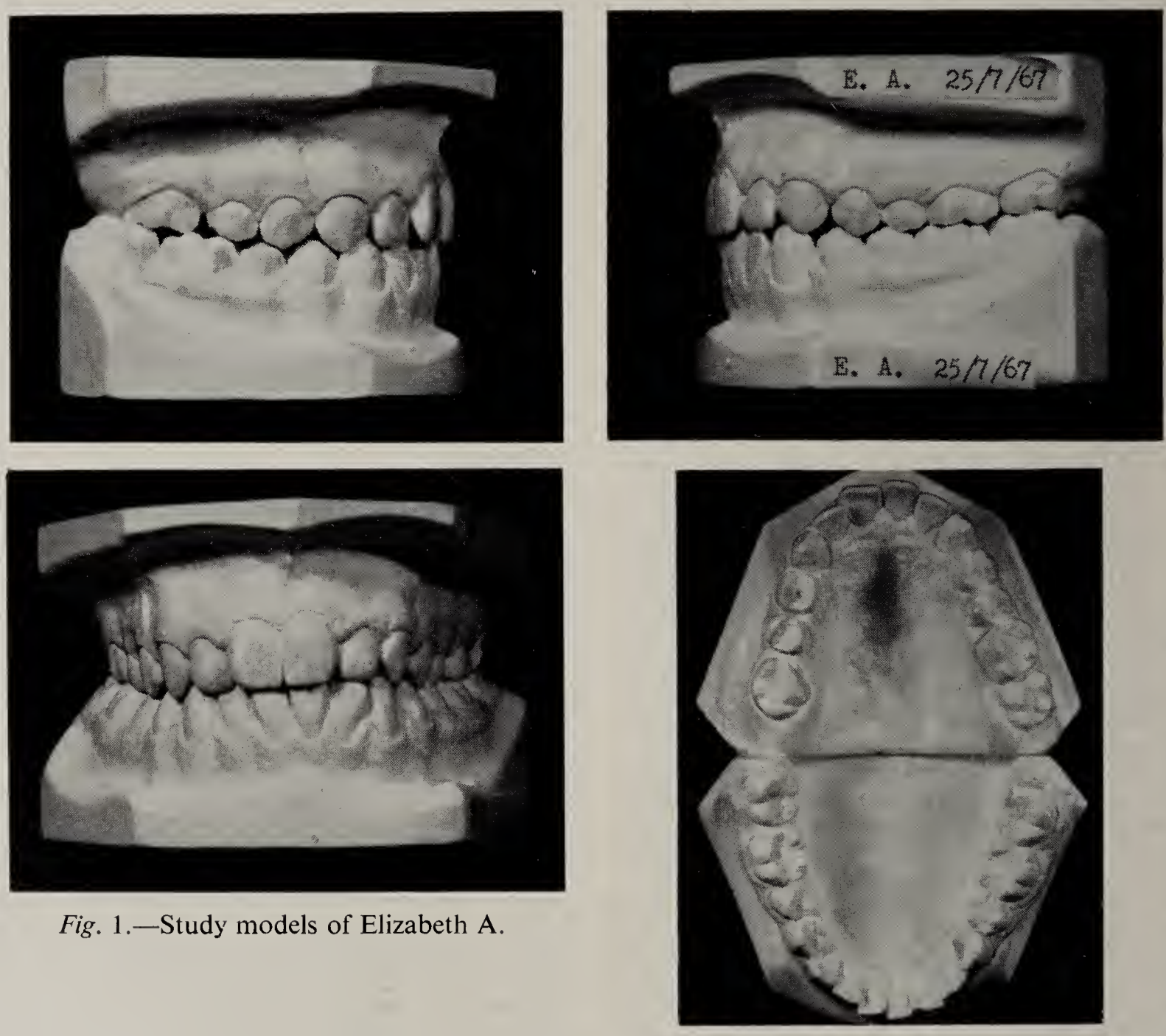

Fig. 1.—Study models of Elizabeth A.

HISTORY OF CONDITION

She had first noticed the sigmatism when she took a speech examination at 11 years of age. She had attended a speech teacher privately after school since 11 years of age and had sat for a series of speech examinations since then. (I later found that the speech teacher taught elocution but in fact had received no training in speech abnormalities whatsoever).

Presented at the Jubilee Meeting held on 10 May, 1968.

Although she had always been successful, she had been taken aside by an examiner each time and given differing advice for her sigmatism. This included being told that the tip of her tongue was too broad and that she should stand in front of the mirror and point her tongue so many times a day—a procedure that Elizabeth soon abandoned as she felt ' a bit of a nit ' doing it. Another told her that her palate was too high, and finally a third suggested there was something wrong with her teeth and advised her to see her dentist. Her dentist referred her to me.

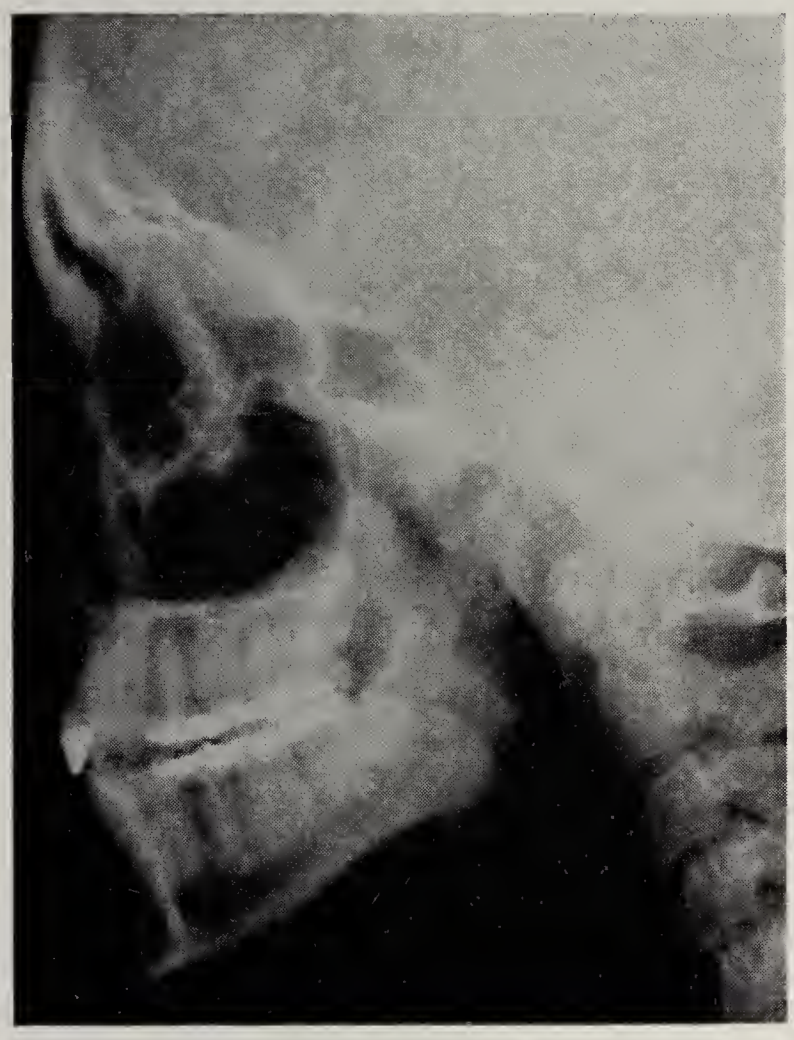

Fig. 2.—Lateral skull radiograph in occlusion of Elizabeth A.

Fig. 3.—Lateral skull radiograph in occlusion when wearing untrimmed bite plate.

Past Dental History

She had had multiple extractions of deciduous teeth at an early age but detailed information could not be obtained. $\underline{6|}$ was extracted in April, 1964.

Past Medical History

At the age of 9 and again at 10 years she had suffered from eczema of her hands lasting both years from May to October only. A medical authority in Belfast considered it to be of emotional origin. After clearing up spontaneously the second year, it has never recurred.

Family History

She has a sister, 18 months younger, with a stammer.

Treatment

As Elizabeth was prepared to try anything if it might assist her to overcome her speech problem, I decided to attempt to help her. Aided by advice from Mr. Peter Vig (personal communication), I fitted a thin acrylic base plate cribbing $\underline{74|46}$ and incorporating posterior overlays. These were trimmed to give an even occlusion when there was an anterior open bite of some 10 mm. (*Fig.* 3). Without giving her any opportunity to practise, I immediately made another tape recording of her speech. I then suggested to her that she should practise speaking with the plate in, and if she felt it was helping her, she could wear it during the daytime at school, but must leave it out at night. I warned her about the likelihood of discomfort. I saw her two weeks later when she was wearing the plate, and clearly there was a considerable improvement in her speech. She admitted to discomfort in the temporal and masseter regions by about 5 p.m. daily. I saw her next some 6 weeks after fitting the plate when she said that the discomfort no longer occurred and she was able to wear it 12 hours at a stretch comfortably. I reduced the bite blocks by some 2 mm. and repeated the process 2 weeks later and again 3 weeks later. Her speech remained improved. Nevertheless, it was obvious that she was greatly concerned about my continuing to trim down the blocks, and on questioning her, she admitted that she was frightened that a relapse in her speech would occur. I attempted to allay her anxiety by saying that I could make her a new plate in a few hours, and even went through the motion of recording the degree of anterior open bite present at that time so that I would be able to reproduce it if the removal of further acrylic were to result in the speech relapsing. I trimmed it again 2 weeks later, again 3 weeks later, and finally, $4\frac{1}{2}$ months after fitting it, I completely removed the overlays leaving just a thin base plate. I gave her instructions to leave out the plate the following Friday immediately after school and to keep it out until she saw me the following Tuesday. I also explained to her that the plate had helped her to learn to make the right speech sounds and now she would

be able to make them without it. She attended next time with the appliance out of her mouth as instructed, looking most unhappy, and speaking with a definite lateral sigmatism which was perhaps more slushy (or less clicky) than her original one. I made a tape recording of her speech. I then got her to replace the plate and immediately recorded her speech again. The improvement was dramatic and one could almost hear how much happier wearing the plate made her. As she was clearly dependent on the plate I agreed that she should continue to wear it. I then arranged for her to attend a speech therapist with me in the hope that it might be possible to wean her off the plate. The speech therapist was able to get Elizabeth to make a correct ' S ' without the plate after guidance for some time but she was not able to incorporate it into continuous speech. Elizabeth has been instructed to practise making a normal 'S ' sound without the plate as much as possible and an attempt will be made, with the help of regular visits to the speech therapist, to wean her off the plate during the long summer holidays from school.

DISCUSSION

The ' S ' sound is an interdental fricative made by the friction or hissing as the breath escapes through a narrow opening anteriorly, having been forced down a narrow groove on the upper surface of the tongue. If the groove is wider, then the ' SH ' sound is made and if air is allowed to escape over one or both sides of the tongue, a lateral sigmatism is produced. Less than 2 per cent of university students have articulatory defects (Morley, 1952) and they are slightly more common in males than in females (1·4:1). Where no organic cause can be found for an articulatory defect, such as the short palate of cleft palate patients, the aetiology is labelled as functional. It is believed that some lateral sigmatisms have their origin in early dental irregularities or lateral spaces in the upper arch, giving rise to patterns of lingual behaviour that are not corrected with the improvement in the dental irregularities. I was not able to confirm whether this theory was, or was not, a possible one in Elizabeth's case. Apparently so-called functional lateral sigmatisms, if still present by the age of 11 years, form a group that is very resistant to corrective training. The results of studies of aetiology of functional articulatory defects are mostly conflicting and confusing, though Wood in 1946 came to some very interesting conclusions: ' . . . functional articulatory defects of children are definitely and significantly associated with maladjustment and undesirable traits on the part of the parents, and that such factors are usually maternally centred.'

My superficial interview with Elizabeth's mother led me to believe that she was unusually ambitious for her but it was impossible to decide to what extent Elizabeth's very active life was the result of pressure from her mother rather than self-motivation. Apart from the speech examinations which necessitates private tuition once a week, she attends dancing classes and is also learning to play the piano and taking examinations for that as well. All this is superimposed on studying for ' O levels '—having been transferred recently to a Technical School from the Intermediate School (equivalent to a Secondary Modern school) which she attended until 15 years of age following failure of the 11-plus examination.

The beneficial effect of the base plate on Elizabeth's present speech is difficult to understand. Van Thal in 1936 stated that: ' The wearing of an appliance appears to have little effect on speech once the wearer has got accustomed to it. Only in 13 cases (out of a total of 180 children studied) was articulation actually worse when wearing the plate or springs; and in 5 cases it was better . . . with the appliance than without it.'

Rothman (1961), in a paper discussing the speech effects of prosthetic appliances, mentioned the relationship between the grooving of the tongue and the ' S ' sound and described how the shape of the denture base could be modified to assist correction of faulty ' S ' sounds. In lateral sigmatism the ' S ' sound could be sharpened by grooving the base plate just behind the upper incisors in an anteroposterior direction. Erb (1967) seemed to find this successful in a very small sample of patients where the procedure was attempted.

Returning to Elizabeth's case, it is unlikely that the arms of the four cribs passing across the occlusal surfaces between the teeth are of any significance. The presence of the plate may serve to ' remind ' her how to produce the necessary lingual behaviour pattern to give a satisfactory ' S ' sound. If this is so, then it should be relatively easy for the speech therapist to teach her to do without it. If it proves difficult, it will indicate presumably that the plate is acting as some form of psychological ' prop ' as well.

CONCLUSION

My encounter with a speech problem proved to be an interesting change from routine orthodontics. By giving me an insight into the complex nature of treating conditions in which the aetiology may have a functional element, it also served to make me appreciate the fact that the occlusal irregularities we are called to treat are largely genetically determined.

Acknowledgements

I would like to thank Miss Kay at the School of Speech Therapy at the Royal Victoria Hospital, Belfast, for her help and interest in this case and Miss Henry for her secretarial assistance.

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DISCUSSION

Mr. D. H. Oliver asked what the speech therapist had to say about the matter.

Mr. M. L. Brenchley said that he had discussed the problem of the girl's speech with the speech therapist before she had seen her. He had played her the tape and she had been very interested in the case. The speech therapist's approach seemed to be very empirical. They talked about ' aggressive types '. Speech therapists seemed to have nothing concrete to offer with regard to the aetiology.

Miss J. Murray asked what had first led Mr. Brenchley to put a plate in. It seemed to be a shot in the dark. Was Mr. Brenchley acting on experience from previous cases?

Mr. Brenchley had drawn attention to the shape of the palate initially; could this have been a factor? Was the plate shaped in any way to regularize the shape of the palate or did it conform anatomically to the palate?

Mr. Brenchley, replying to the first part of the question, said that when he examined the girl, he could see the tongue escaping posteriorly all the time she was making the ' S ' sound. When he looked into the mouth immediately afterwards, the tongue was actually indented for a moment. He thought that if one was going to do anything at all, it would be nice to stop up the openings at the side where the tongue was escaping, tackling it purely empirically. He had got in touch with Mr. Peter Vig who had had some experience in this subject and offered advice so that he used an upper appliance rather than a lower one. The plate was constructed from one layer of wax with no special alteration.

Mr. A. J. Walpole Day asked whether Mr. Brenchley had had the pleasure of doing orthodontic treatment on a speech therapist, or if anyone else present had. He had been fortunate enough to have this experience and afterwards, the speech therapist said that she was very glad she had gone through this ordeal because it had made her speech very much better. She had been conscious of what her tongue was doing all the time in order to get her words out correctly, and when the plate was in not only did it make her teeth better but it made her speech better as well.

CEMENTS FOR ORTHODONTIC USE

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In orthodontic work, cement is used to retain bands in position and to occupy the space between band and tooth, preventing plaque formation and subsequent enamel decalcification.

This investigation was prompted by dissatisfaction with the setting characteristics of a zinc phosphate cement used in our orthodontic department. Adequate information on which to base a choice of cement was not available, and it was decided to compare properties of clinical importance of various brands of cement. Working time, setting time, rate of strength development, and solubility were investigated. Adhesion was not studied as it is generally agreed that present dental cements lack adhesion under wet conditions (Skinner and Phillips, 1967). Film thickness is not of such importance in cementing bands as in crown and inlay work and it is possible to consider the use of cements such as the silicophosphates which have an inherently great film thickness. A trial to compare the clinical effectiveness of the two different types of cement was carried out in an attempt to assess the validity of laboratory tests.

MATERIALS AND METHODS

Table I shows the selection of cements tested. The suffix Z indicates zinc cements, B, black copper cements, and S, silicophosphate cements.

To permit comparisons, cements must be mixed to the same consistency. This is measured as the diameter of a disk produced by compressing a given volume of mixed cement under a standard load. The Fédération Dentaire International (F.D.I.) specifications lay down a consistency for zinc phosphate cements which is too fluid for orthodontic use, being designed for cementation of inlays. In this work, 0·5 ml. of mixed cement gave a circle 25–26 mm. in diameter when compressed between glass plates under a load of 520 g. The same criterion was used for silicophosphates but this mix was thinner than the standard specified for silicate filling materials (*Table I*). These consistencies are similar to those selected by Cameron, Charbeneau, and Craig (1963) who averaged the usage of thirteen orthodontists.

The method of mixing zinc cements influences their working and setting times and a simple method, suitable for clinical use, was adopted. For the zinc phosphates the powder was divided into four equal portions, one portion being halved. Starting with the smallest they were incorporated into the liquid at 15-second intervals, the whole mixing operation taking $1\frac{1}{2}$ minutes. A slow mixing procedure is important as too rapid incorporation of powder will result in a much reduced working time. Black copper cements were also mixed in this way. The powder for the silicophosphates was divided into three portions (one half and two quarters incorporated at 15-second intervals), the procedure being complete within 1 minute.

Cements were all mixed in a room of controlled temperature (21° C.) on a slab maintained at 21° C.

Working Time (at 21° C.)

Working time is a difficult property to assess objectively but this was attempted using a reciprocating rheometer similar to the 'curemeter' used by Wilson (1964) in his investigation into the setting of impression materials. This instrument has two parallel stainless-steel plates between which the mixed cement is placed. The lower plate is given a slow reciprocating movement by a geared electric motor. As the mix thickens, the upper plate starts to move and this movement (magnified ten times) is recorded by a pen on a rotating drum. A diverging trace is produced (*Fig.* 1) and working time is taken as being the distance to the inflection of the curve (*Table I*).

Setting Time (at 37° C.)

This was measured in the conventional manner as being the time taken from beginning the mix until a 1 lb. Gillmore needle failed to indent the surface (*Table I*).

Presented at the Jubilee Meeting held on 10 May, 1968.

On setting, the strength of cements is low and is not considered to be adequate to allow a band to be loaded by tying in an arch. Even if the band is not unseated, properties of the cement may be impaired.

Strength

The contribution of cement to retention of bands is complex. There is little adhesion at either cement-enamel or cement-band interface and it has been suggested (Skinner and Phillips, 1967) that cement acts as a luting agent which, by occupying interstices between tooth and band, wedges the band in position. If this is so, standard compressive tests probably give a reasonable indication of the strength of cement in function. Crushing strengths of test cylinders of cements were measured on a Hounsfield tensometer in the conventional way. In the specification tests, strength is measured after 24 hours. Early strength is also of interest in orthodontic work and graphs were constructed by plotting the strength of cements at intervals of 10, 15, 20, and 60 minutes as well as after 24 hours in water. Although the ultimate compressive strength of silicophosphates is greater than that of zinc cements, early strengths are lower and they take longer to reach a reasonable working strength.

As an index, it is suggested that a reasonable minimum working strength would be 50 per cent of the F.D.I. standard specification No. 6 for zinc cements. It can be seen that several cements reach this strength by 15 minutes (*Table I*) and it is doubtful whether those which fail to do so are suitable for orthodontic use.

In order to investigate the strength of cement in function, a jig similar to that used by Williams, Swartz, and Phillips (1965), was constructed to measure the force required to remove bands cemented to extracted teeth. Only one representative of each group of cements was tested. Teeth were banded, polished, and bands cemented with one of the cements. One hour later the tooth was immersed in water, and after 24 hours the band was withdrawn from the tooth. Teeth and bands were cleaned and polished and the operation was repeated for the second and then for the third cement. The order in which cements were applied to any tooth was strictly random.

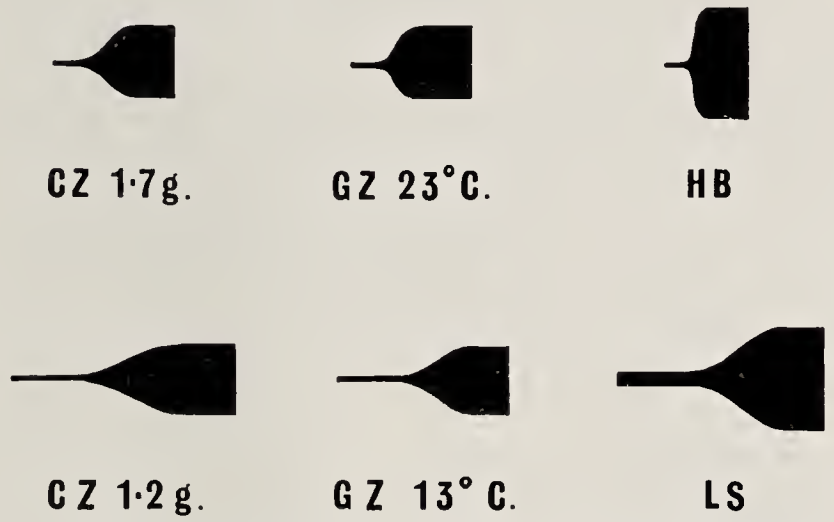

Fig. 1.—Rheometer traces of working times illustrating the effect of powder-liquid ratio (CZ at 1·7 g. and 1·2 g. powder in 0·5 ml. liquid) and of temperature (GZ at 23° C. and 13° C.).

There was some variation between tests on the same tooth with the same cement but the average force required to withdraw bands cemented to teeth did not bear a direct relationship to the compressive strength of the cement (*Table II*). This is in agreement with the findings of Williams and others (1965) on cementation of orthodontic bands, and of Oldham, Swartz, and Phillips

Table I.—Properties of Cements

Cement	Code	Powder in 0·5 ml. Liquid (g.)	Working Time at 21° C. (min.)	Setting Time at 37° C. (min.)	Strength		Solubility (mg. per day at 14 days)	
					Time to reach $5{\cdot}0 \times 10^3$ p.s.i. (min.)	After 24 hr. p.s.i. $\times 10^3$	Water (*p*H 5·5)	Lactic acid (*p*H 4)
Alston zinc	AZ	1·2	3	7½	11	10·4	0·6	0·8
Ames' crown and bridge	BZ	1·15	3	10½	18	18·4	0·6	NA‡
De Trey's zinc cement improved	CZ	1·7	4¼	7½	10★	11·5	0·1	0·2
Fleck's cement extraordinary	DZ	1·75	3½	9	11	18·3	0·1	NA
Racim zinc phosphate	EZ	1·3	4½	6½	8★	14·4	0·1	0·8
S.S. White zinc cement improved	FZ	1·7	3	6	11	13·1	0·1	NA
Tenet Universal oxyphosphate	GZ	1·5	4	9	11	11·0	0·1	NA
Ames' copper	HB	2·5	3	5½	10	23·0	2·3	3·2
De Trey's copper cement black	JB	2·0	4½	7	10★	17·8	0·05	NA
De Trey's silicophosphate	KS	1·55	6	6	12	27·2	0·9	1·8
New Kryptex	LS	1·65	6½	5½	9★	21·0	1·1	2·2
Petralit silicophosphate porcelain	MS	1·45	4½	10	15	21·5	0·1	0·3
Solila cement improved†	NS	1·45	11	14	26	24·0	0·2	0·3

★ Strength exceeded at this time but earlier readings not available
† No longer available
‡ NA Results not available

(1964) on cementing inlays, and suggests that some factor other than strength contributes to retentiveness. Adhesion must be discounted but it is possible that some cements adapt better to minute irregularities of tooth and band, thus improving retentiveness.

In these tests it was almost always the band-cement junction which failed, suggesting that roughening the band with a stone might improve retention (provided, of course, that the tooth itself was adequately cleaned and dried).

Table II.—Comparative Strengths of Different Cements in Function

Cement	Compressive Strength (p.s.i. $\times 10^3$)	Average Force to remove Bands (lb.)
Zinc phosphate (De Trey's)	11·5	42·8
Silicophosphate (Kryptex)	21·0	41·1
Black copper (Ames')	23·0	38·5

Solubility

An excessively soluble cement will rapidly leach out from band margins—possibly undetected—and allow plaque formation with risk of subsequent enamel decalcification. Solubility-time graphs were constructed for all cements tested. Distilled water is conventionally used but this may not give a reliable index of the relative clinical solubility of cements from different groups. It has been claimed that in dilute organic acids (e.g., lactic acid) the relative solubility of zinc phosphate and silicophosphate cements is reversed (Norman, Swartz, and Phillips, 1959) and it is possible that such solutions are somewhat nearer to mouth conditions—particularly where there is plaque. For this reason the solubility of cements was tested both in distilled water, *p*H 5·5, and in lactic acid solution, *p*H 4 (*Table I*).

Silicophosphate cements were consistently more soluble than zinc cements. This applied to tests both in distilled water and in lactic acid. These findings differ from those of Norman and others (1959) who reported that the relative solubility of zinc and silicophosphate cements was reversed in dilute organic acid. This might be due to the fact that buffered solutions were not used in the present investigation with the result that *p*H rose with dissolution of cement. However, solutions were changed daily and it is possible that buffering salts could themselves influence cement solubility.

The solubility of silicophosphate cements drops rapidly but is consistently higher than that of zinc cements. The high initial solubility of silicophosphate cements is due to leaching out of soluble reaction products from the set cement (Wilson and Batchelor, 1967) and probably is not of importance as far as durability of the cement is concerned.

Effects on Enamel

It has been suggested (Castello, Massler, Monteleone, and Suher, 1948) that cements containing acid would etch enamel surfaces. Reports are conflicting but the general consensus of opinion seems to be that etching is not likely to follow the use of normal cement mixes. Docking, Donnison, Newbury, and Storey (1952) using a collodion replica technique were able to demonstrate etching only when very thin mixes were used. An increase in permeability of enamel surfaces to certain dyes, even when no surface damage could be detected by other methods, was produced by somewhat thicker mixes. However, with normal clinical mixes, no damage to enamel was demonstrable. Seniff (1962) also produced etching with thin mixes and showed that this was reduced by prior application of 8 per cent stannous fluoride.

Silicophosphate and zinc phosphate cements, in normal mixes, reach *p*H 5 in less than 1 hour but Type 1 black copper cements remain below *p*H 5 for over 24 hours (Norman, Swartz, and Phillips, 1966). It would be expected that damage would be more severe under black copper cements.

Docking's use of methyl violet to determine changes in permeability of enamel is both sensitive and simple and this method was used in present experiments.

Freshly extracted premolar teeth were cleaned and polished, one half of the buccal surface of the crown was masked with nail varnish and the cement to be tested was applied to the entire surface and left *in situ* for 24 hours. Cement and nail varnish were removed and the crown was immersed in methyl violet solution (1 per cent) for 1 hour. An increase in surface permeability of exposed enamel was demonstrated with cement liquid and with very thin mixes but no change was demonstrable with even the thinnest usable mix. In another series of teeth, a second mix was applied after removal of the first, but results were the same.

It may be concluded from these experiments that clinically detectable etching of enamel is not likely to be produced by usable cement mixes, at least in previously sound teeth. Any surface damage must be the result of cement disintegration followed by acid decalcification.

Other enamel changes are produced by cements. It has been shown (Norman, Platt, Phillips, and Swartz, 1961) that fluoride is taken up by enamel from silicate cements and dark staining of enamel is sometimes seen following the use of copper

cements. The possibility of such fluoride uptake affecting caries resistance of teeth was not investigated in this work.

DISCUSSION OF LABORATORY TESTS

Desirable properties of cement depend to some extent on the operation to be undertaken. For a multibanded appliance, a working time sufficiently long to allow cementation of all bands in one arch with one mix would be helpful. This should be followed reasonably shortly by the set and by attainment of sufficient working strength of the cement. Silicophosphates offer advantages in this respect. Kryptex for example has an effective working time of $5\frac{1}{2}$ minutes ($6\frac{1}{2}$ minutes less 1 minute for mixing) and sets very rapidly afterwards.

Zinc cements have a shorter working time and reach a working strength more quickly. For the cementation of only one or two bands, this would be an advantage.

The variation within each group is considerable, e.g., cement BZ with an effective working time of only $1\frac{1}{2}$ minutes takes very much longer to set and to reach a working strength than does cement CZ which has nearly double the working time.

Effective working time can be manipulated to some extent by powder-liquid ratio, rate of mixing, temperature of slab, etc. Powder-liquid ratio is fairly critical for long-term properties of the cement and slab temperature is probably the best method of controlling working time.

As far as cement durability is concerned solubility is of prime importance. Silicophosphate cements have solubilities consistently higher than those of zinc cements but results of laboratory tests in comparing cements from different groups must be viewed with reserve. However, laboratory tests probably give a reasonable index of relative clinical solubility of cements from the same group. Most zinc cements have a very low solubility but the more soluble brands might be expected to have a correspondingly reduced clinical life. The silicophosphate group shows considerable variation. Two cements, KS and LS, have a solubility similar to that of silicate cements. Although this is very much higher than that of zinc cements, it may not reflect a corresponding reduction in clinical life. The silicophosphate cements MS and NS have very low solubilities similar to those of zinc cements. This may be due to a relatively high content of zinc phosphate with a correspondingly low silicate proportion. Both these cements have inconveniently long setting times and for this reason are probably not particularly suited to orthodontic use.

All cements show some degree of dissolution and disintegration in mouth fluids. Damage to enamel surfaces beneath orthodontic bands must be attributed to acid decalcification following cement loss. Complete cement loss should be obvious but localized loss can be difficult to detect. For this reason it is suggested that bands should be routinely re-cemented at intervals of 9 months to 1 year—about half-way through the average course of treatment.

There are two types of black copper cements (Skinner and Phillips, 1967). Type 2, of which JB is an example, are similar in their properties to zinc cements. Type 1 black copper cements such as HB do not appear to give any appreciable advantages. They are rather soluble in the test fluids and although compressive strength is high, they do not appear to give superior retention of bands. They are not pleasant to work with and there is danger of discoloration of enamel following their use.

Within the zinc phosphate and silicophosphate groups, the range of properties is considerable but the better cements in each group have reasonably satisfactory characteristics. Neither group has outstandingly superior properties for orthodontic usage. However, laboratory tests by isolating individual factors for investigation, might give a misleading picture particularly when comparing cements from different groups. The second part of this paper reports an attempt to evaluate whether, in clinical use, one group of cements would offer appreciable advantages. A representative zinc cement (De Trey's) was compared with a silicophosphate cement (Kryptex).

CLINICAL TRIAL

Three operators took part in the trial but all cements were mixed by one dental nurse. Patients who were to have bands cemented to the equivalent tooth on each side of one arch were selected. Bands were made and teeth cleaned and polished. The left band was always cemented first, but the cement allocated to that band was chosen by reference to a previously established, strictly random list. The other band was cemented using the alternative cement. Powder had previously been weighed out into plastic containers and liquid was dispensed from an accurately graduated syringe. The standardized mixing procedure was carried out on a slab maintained at 21° C. and was timed by a stop watch. Bands were not tied into the arch for at least 10 minutes after commencing the mix for the second band.

Table III.—Clinical Trial

Result	No. of Patients
Failed (De Trey's zinc phosphate)	8
Failed (Kryptex silicophosphate)	4
Both failed	1
Neither failed	39

Only one pair of bands from each patient was entered into the trial and these were inspected at every visit. Failure was recorded if the band became displaced, if cement had leached out from under a band to a depth of more than 1 mm. below the edge of the band, or if the band had to be re-cemented for any reason associated with failure of the cement.

If bands had to be removed for reasons unconnected with cement failure, the patient was discharged from the trial.

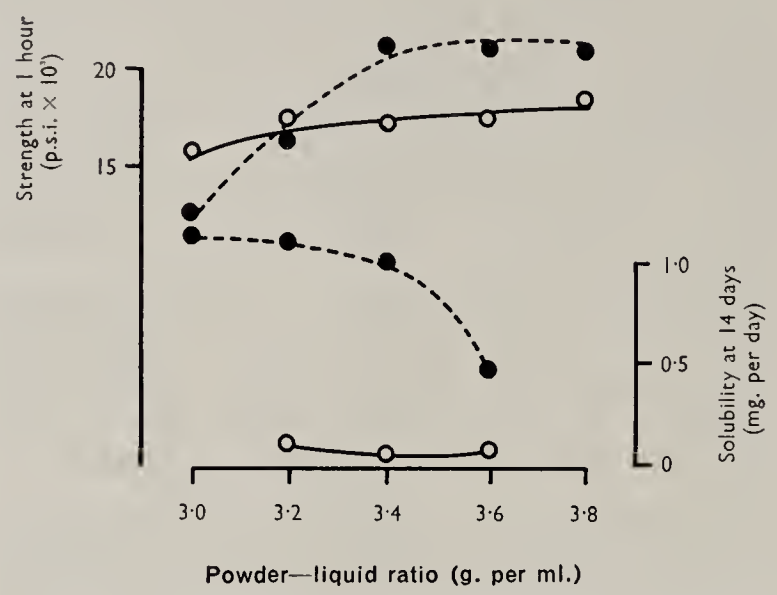

Fig. 2.—Effect of powder-liquid ratio on strength and solubility of two cements. Solid line: zinc cement; broken line: silicophosphate.

The trial was terminated after 18 months and results are shown in *Table III*. Twice as many bands failed with zinc phosphate cement (De Trey's) as with silicophosphate cement (Kryptex) but the difference is not statistically significant (χ^2 for paired observations is 1·3).

It may be concluded from the clinical trial that there is little to choose between silicophosphate and zinc phosphate cements as far as durability is concerned. Careful handling of cements is important and it was remarked by all three operators that bands used in the trial seemed to fail less frequently than other bands in the same patients. This was attributed to accurate proportioning and careful mixing technique. An investigation into the powder-liquid ratios used by 20 individuals (for cementing bands) showed that these varied from $1\frac{1}{2}$ to 2 g. of powder per 0·5 ml. liquid for both the zinc phosphate and the silicophosphate cements. *Fig.* 2 shows the effects of such variation in powder-liquid ratios on the strength and solubilities of these two cements.

It appears that the zinc cement is less sensitive to changes in powder-liquid ratio than is the silicophosphate. Within the range studied, higher powder-liquid ratios gave greater strengths and lesser solubilities. Powder-liquid ratios employed in this study for these cement brands were less than optimum for strength and solubility. An increase in powder-liquid ratio of the zinc cement would result in an inconvenient reduction in working time but the silicophosphate powder-liquid ratio could have been increased with advantage.

CONCLUSIONS

The tests for the standard specifications may be adequate for comparison of cements within one group but must be interpreted with caution when comparing cements from different groups. Although silicophosphate cements have a greater ultimate compressive strength than do zinc cements, early strengths are lower and retentiveness is not necessarily greater. Setting time does not give a good estimate of working time but does give some indication of the rate of strength development.

Solubility in test solutions is not an accurate index of clinical durability when comparing cements from different groups. The test solubility of silicophosphate cements is several times that of zinc cements but their clinical life is at least as great.

Zinc cements which do not comply with the F.D.I. standard specification No. 6 are probably not suitable for orthodontic use. Two of the silicophosphates tested seemed suitable for orthodontic usage.

The choice of cement must remain a matter of personal preference but the better cements from each group give reasonably satisfactory working characteristics, provided they are handled with care.

SUMMARY

Seven zinc cements, two black copper cements, and four silicophosphate cements were tested with reference to their suitability for cementation of orthodontic bands.

The range of properties within each group is considerable. Black copper cements are not well suited to routine orthodontic use but the better cements from the silicophosphate and zinc phosphate groups offer some advantages.

Zinc cements have a rather short working time but reach a working strength quite rapidly. Silicophosphates have a longer working time but take longer to reach the same strength; their ultimate strength is greater but they are not more retentive than zinc cements; their solubility in test fluids is greater but their clinical durability is not less than that of zinc cements; they are more sensitive to incorrect handling.

Neither group was outstandingly superior but each would offer some advantages in specific clinical situations.

Acknowledgements

We wish to thank Mrs. A. M. McDonald, Mr. K. G. Isaacson, and Mr. H. B. Valentine who

took part in the clinical trial, Mr. J. Turnbull who constructed the rheometer, and Miss V. M. Dennis for secretarial assistance.

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DISCUSSION

Mr. G. C. Dickson said that it had been pointed out to him quite a long time ago that the very dark shade of cement, shade 9, apparently displayed different properties from the lighter colours, and, in fact, working with it, this appeared to be so. He wondered if the different shades had been tested and whether there was any physical difference between them or was it just his imagination?

Mr. Houston replied that only one shade had been tested—No. 3. Mr. Miller might be able to give further information.

Mr. Miller said that the lighter shades were normally used since it was then easier to see what one was doing with them. The only suggestion he could offer was that this was a shade which was perhaps not used very frequently and therefore the number of batches from the manufacturer was fairly small.

Mr. P. R. W. Coyle asked if the properties of the red copper cements were similar to those of the black copper; if not, had Mr. Houston not considered trying these out?

Mr. Houston said that in this trial red copper cements had not been tested. He thought it important to recognize that Ames' black copper cement was rather peculiar. De Trey's black copper cement and other copper-containing cements behaved in a very similar fashion to normal zinc cements.

Mr. D. F. Glass referred to the matter of wetness and said that when splints and things like that were put on, people often used black copper cement because they said it set better and more strongly if everything was wet. Quite often, orthodontic teeth were not quite dry. He asked if any trials had been done on the different cements without drying the teeth.

Mr. Houston replied that such trials had not been carried out. He thought that it had been well established that adhesion in its true sense did not exist at cement-enamel interfaces. All present cements relied purely on mechanical interlocking with minute surface irregularities. Obviously, if the surface were wet, such interlocking were much less likely to take place. All tests had been done on teeth that had been thoroughly dried—more thoroughly than was possible when cementing splints.

Mr. E. J. R. Bird asked if the Ames' cement was a crown and bridge cement or ordinary cement.

Mr. Houston replied that the Ames' cement was crown and bridge cement with 'C' liquid. They had also used Ames' black copper cement.

Mr. A. J. Walpole Day referred to the different physical properties of the silicate and zinc cements and said that the zinc cements were thinner and spread more easily, therefore adapting to the tooth surface better. He remembered being told many years ago never to use zinc cement because it might hold the band on when half the cement had already disappeared and caries might be produced between the band and the tooth without one realizing it. Therefore, silicate cement should be used, which was slightly rougher with no adhesion at all to the surface.

Mr. Houston replied that this was more or less the explanation being put forward. They had expected that the very much stronger silicophosphate cement would retain bands better on teeth, but it did not. The explanation put forward was that zinc cements adapted better to minute surface irregularities. Whether, when some of the cement was dissolved away, bands were more likely to fall off with silicophosphates than with zinc cements he would not like to say. They felt that all cements disintegrated in mouth fluids to some extent and that regular servicing of bands was absolutely essential.

A NEW CLINICAL, STUDIO, AND LABORATORY PHOTOGRAPHIC UNIT

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THERE are two principal difficulties in dental photography which are:—

1. It is not possible with any camera available today, in its standard form as normally supplied by the manufacturer, to take photographs of the small areas which are commonly required in dental illustrations. For such work accessories and special arrangements are always required.

2. A special lighting unit, usually an electronic ring light, is required and has to be provided and fitted separately. Such a light is useful for the illumination of the oral cavity, but is not suitable for the photography of solid objects or for portraits.

All in all, the dental photographer has to make shift with existing equipment and adapt it to his special needs as best he may. With these problems in mind the present camera unit was designed to provide within one compact piece of equipment everything that would be required for any dental photographic problem. It follows that such a unit would be of the greatest value in many other branches of photography in museums, laboratories, or in medical photography (*Fig.* 1).

The unit provides the following facilities:—

1. An interchangeable 35 mm. reflex camera body giving full screen viewing at all scales of reproduction. Shutter speeds B and 1–1/1000 sec.; flash synchronized.

2. 10 cm. lens with automatic diaphragm.

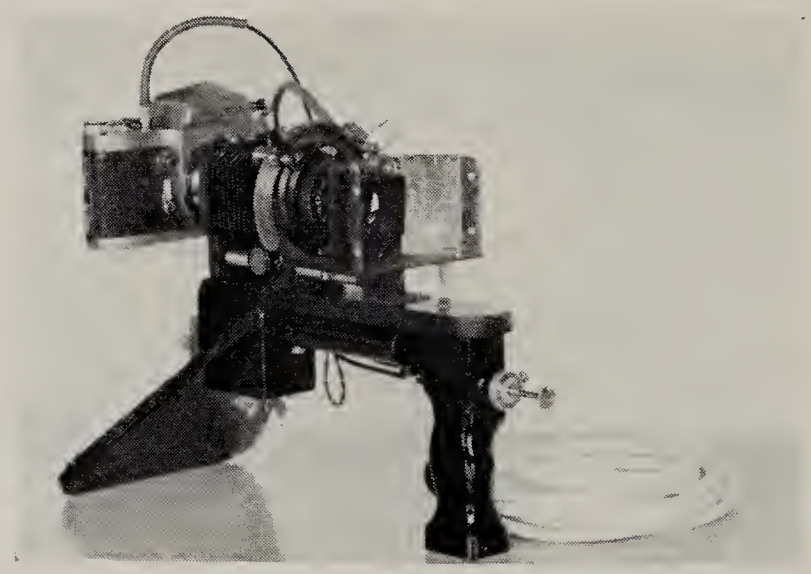

Fig. 1.—The new clinical, studio, and laboratory photographic unit, Mark II. This unit is based on a single lens miniature reflex camera and 10 cm. lens, with automatic diaphragm. The lens can be focused over a range from infinity to a ratio of 1:1. By using a single supplementary lens, the ratio of reproduction can be increased to a magnification of 2:1. A self-contained flashlight for cavity or surface illumination, an automatic focusing light, and shoulder rest complete the unit.

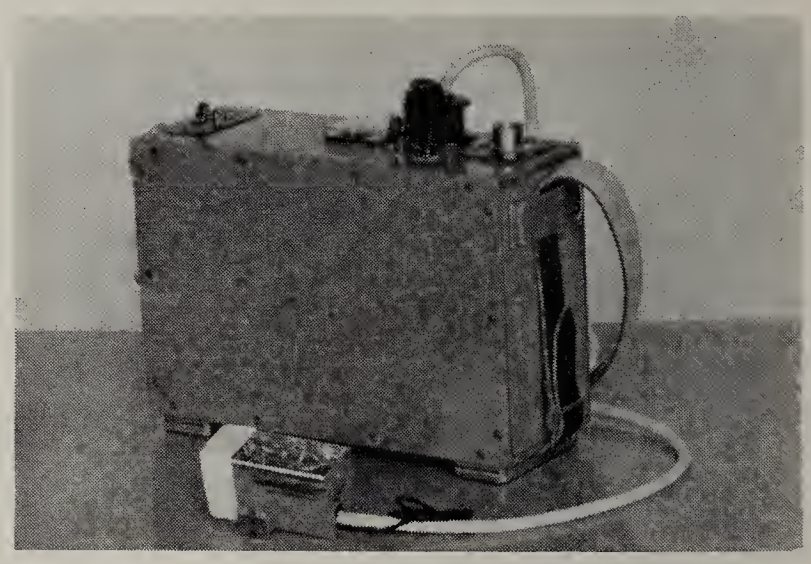

Fig. 2.—The power unit and compact electronic flashlight. The flashlamp accepts a 150-watt-second loading and the mains operated power unit will deliver from 25 watt-seconds up to 250 watt-seconds as required. The power unit measures $10 \times 7 \times 4$ in., the light source measures $2\frac{1}{4} \times 1\frac{1}{4}$ in. Two or three lamps may be fixed simultaneously from the power pack.

3. Focusing range from infinity down to a ratio of 1:1 *without the use of any extra parts.* With the addition of *one* supplementary lens the focusing range can be extended to a ratio of 2:1.

4. The unit contains its own lighting system for cavity illumination. Lighting for cavity or external surfaces may be by electronic discharge tube, *Fig.* 2, or by expendable bulb as suits the user. In both cases a single light source is used. It must be emphasized that full cavity illumination is effected by the use of a single flashbulb if wanted. *No ring flash is used.* The value of this

Demonstration at the Jubilee Meeting held on 10 May, 1968.

arrangement for producing polarizing effects, when required, must be obvious. If the user insists on having a ring flash this can be provided as a special item.

5. The camera is calibrated in ratios of reproduction through the range—1:13, 1:10, 1:8, 1:6, 1:4, 1:3, 1:2, 1:1·5, 1:1, 1·5:1, and 2:1. The ratio is, however, infinitely variable from infinity to 2:1.

6. A focusing light is provided for the illumination of cavities and close-up situations while focusing the lens. This light is extinguished automatically when the shutter is released.

7. Two filter slots are provided so that card-mounted gelatin filters can be used. These filters are optically superior, exceedingly cheap, and available in an immense range for various purposes.

8. There is an integral camera stand, chest support, and pistol grip placed well forward ensuring freedom from shake when using the camera hand held. The unit sits down steadily on the bench when not in use.

9. The camera may be used on a tripod if required.

Fig. 3.—A full figure may be photographed at 17 ft. distance. This is a daylight exposure taken on 125 A.S.A. film $\frac{1}{2}$ sec. at f11. If space is restricted the miniature reflex camera may be used with its standard lens at a distance of 8 ft. or with a short focus lens at even closer range for full length pictures. If space is not a problem, the new clinical camera gives very pleasing perspective at the longer distance. (*Figs*. 3–5 *reproduced from 'Dental Photography' by C. P. Adams, published by John Wright & Sons Ltd.*)

Fig. 4.—Full face and profile views are taken at a distance of 4 ft. 4 in. The head fills the miniature frame and there is no distortion of the features.

In practice the camera is extraordinarily comfortable and speedy to use. The scale of reproduction is chosen first and set, the appropriate lens aperture and power setting in the electronic pack are set, the subject lined up, and the exposure made.

Fig. 5.—The left upper third molar photographed at 1·75:1.

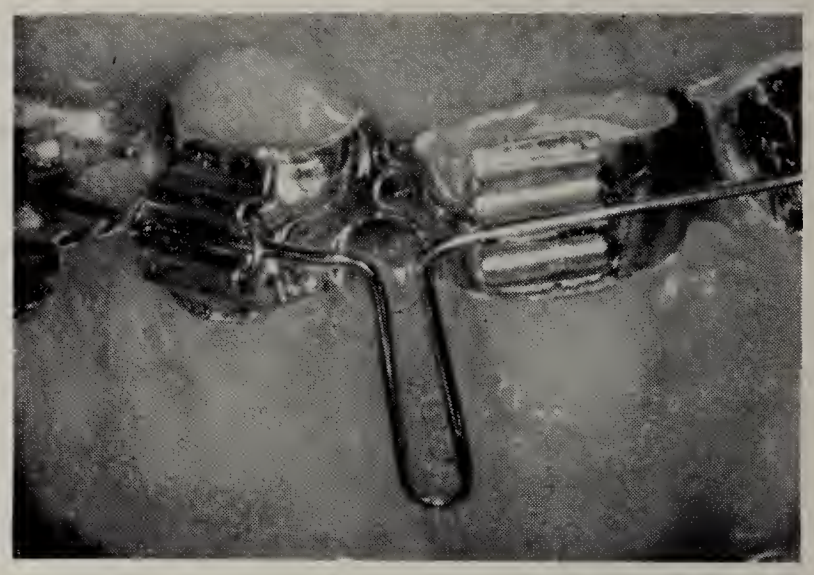

Fig. 6.—A light wire appliance photographed at 3·5:1.

For the ratios 1:4 to 2:1 the flashlamp is used in the lens position. For the ratios 1:13 to 1:6 the light is used in the top position, a little above and to one side of the lens.

When using the camera on a tripod for studio and table top work it will often be found better to use daylight, Anglepoise lamps, or studio lighting with normal exposure reckoning methods.

In its clinical form the camera can be used for full face and profile views and close-ups of varying degrees, down to ×2 magnification of teeth and tooth restorations, on colour slides. The effectiveness of the illumination in lighting the inside of dark cavities is soon apparent.

The versatility of the lens chosen for this unit is well shown in the fact that in the full length view, an excessively long distance is not required (17 ft.); in the full face view at a ratio of 1:13 the miniature negative format is filled and yet there is no facial distortion; it is, with the same lens, possible to give the extension necessary to provide a reproduction ratio of 1:1 and to increase this to 2:1 by using one supplementary lens without sacrifice of optical performance (*Figs.* 3, 4, 5, 6).

This is a camera which can be used for all scientific purposes.

THE EARLY TREATMENT OF ANGLE'S CLASS II, DIVISION 1 MALOCCLUSION

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In this country, the most frequently employed method of treating Angle's Class II, division 1 malocclusion is to delay treatment until the upper permanent cheek teeth have erupted, when if necessary, permanent teeth can be extracted to relieve the crowding and provide space for the reduction of the overjet. The upper canines are usually then moved distally before the incisors are retracted, the patient being on average between 11 and 13 years of age; by the time treatment is completed the patient may be aged 14 years or more.

For the purpose of this paper, early treatment means appliance therapy to retract the upper incisors carried out at some time after the eruption of all of the permanent incisors, but before the eruption of $\underline{3|3}$; the patient commonly being between 8 and 11 years of age. The term 'Angle's Class II, division 1 malocclusion' refers only to the relationship of the incisors, that is, the overjet is increased.

METHODS OF EARLY TREATMENT

The correction of this condition in the mixed dentition receives varying emphasis in the textbooks of orthodontics and often only brief reference is made to it, if any at all. There are exceptions and basically three methods of treatment emerge:—

1. Several authors mention the use of simple upper removable appliances following the extraction of $\underline{C|C}$ or $\underline{D|D}$ if required, while Tweed (1966) describes the early use of the edgewise appliance and in discrepancy cases he extracts $\frac{D|D}{D|D}$ and $\frac{4C|C4}{4C|C4}$ to a special timetable, beginning appliance therapy approximately fifteen months prior to the normal eruption of the second premolars and second molars.

2. Fischer (1957), Graber (1961), and others advocate the early application of extra-oral traction to mesially placed $\underline{6|6}$, before $\underline{7|7}$ have developed sufficiently to impede their progress distally, when also the bone is more responsive and the maxilla is still growing forwards, so that lighter forces are effective; but the head gear has to be tolerated for a considerable period.

3. Haupl, Grossman, and Clarkson (1952), Lundström (1960), and others state that the Andresen appliance is most effectively used during this period, especially when there is unfavourable soft-tissue behaviour, although not all cases are suitable for this appliance due to its effect on the lower arch.

While the more complex appliances may be indicated occasionally, they are not normally essential for the early reduction of an increased overjet and only simple removable appliances have been used to treat the 15 cases which form the basis of this paper. By reviewing these cases, criteria for consideration when selecting suitable patients for this technique have become apparent, and it is concluded that by treating in the late mixed dentition so that, ideally, $\underline{3|3}$ erupt soon after the overjet has been reduced, most of the advantages of early treatment are retained while some of its possible disadvantages are avoided or at least reduced. The patient is between 10 and 12 years of age during appliance therapy and treatment is completed at the time when normally it would just be starting.

THE TECHNIQUE OF EARLY REMOVABLE APPLIANCE THERAPY

During the examination of the patient special care must be taken to see that there are no abnormalities of the unerupted permanent dentition and that $\underline{3|3}$ are positioned close to the line of the arch. Extra-oral lateral oblique radiographs are supplemented with intra-oral films of the maxilla and they should be carefully examined for evidence of hypoplasia or rotation of $\underline{5|5}$, and rarely the crowns of $\underline{3|3}$ may be rotated or of abnormal form. The positions of $\underline{3|3}$ are found by palpation together with the parallax method using the intra-oral films (*Fig.* 1), and if there is any doubt a vertex-occlusal view can be taken. In addition, a lateral skull or profile

Presented at the Jubilee Meeting held on 11 May, 1968.

view is desirable to show the direction of their long axes.

When there is insufficient space in the upper arch to accommodate temporarily the retracted incisors, C|C are extracted, and an upper removable appliance (*Fig.* 2) is then inserted comprising Adams clasps on 6|6, a labial spring to retract the incisors, and, if necessary, a flat anterior bite plane to reduce the overbite.

Late mixed dentition therapy is begun when the mesial contact points of the crowns of unerupted 3|3 are level with the middle third of the roots of 2|2 (*Fig.* 1), and subsequently 3|3 will frequently erupt within a year. If 3|3 are lower than this it is still possible to retract the upper incisors, provided 4|4 are first removed when the upper arch is crowded.

Following the reduction of the overjet the appliance is modified to retain the incisors and retention is maintained at night-time for 6 months, in order to allow the periodontal membrane to reorganize (Reitan, 1967). The retainer is then progressively withdrawn and if there is any tendency for the incisors to relapse by more than 1 or 2 mm., retention is continued until 3|3 have erupted and any crowding relieved, the patient attending every 2 to 3 months.

The upper first premolars are extracted on eruption if crowding is present and it is anticipated that future growth will not accommodate them. Should it be apparent from the radiographs that 3|3 are likely to erupt before 4|4, then D|D are extracted after the overjet has been reduced to hasten their eruption, and if this fails

A

B

Fig. 1A, B.—Intra-oral radiographs of 3| showing the stage of eruption when late mixed dentition treatment is normally begun, so that 3| usually erupts within a year. By using the parallax method, 3| is seen to be slightly labially placed.

A

B

Fig. 2A, B.—Upper removable appliance used to retract 21|12 and reduce the overbite, comprising:—Adams clasps on 6|6; a flat anterior bite plane which is progressively trimmed clear of 21|12 as they are retracted; and a labial spring, consisting of a 0·8 mm. outer labial bow with a sliding 0·45 mm. Jackson spring soldered and coiled around the mesial arm of one U-loop, which is activated by closing the U-loops.

4|4 are enucleated just before the eruption of 3|3, when they will be found close to the surface.

REASONS FOR EARLY TREATMENT

Early treatment is conventionally undertaken for preventive or psychological reasons and so these will be considered first, but there are several other incidental advantages which have practical application.

Preventive Treatment

This is undertaken either to reduce the risk of damage to the upper incisors from trauma, or rarely in an attempt to improve the health of the upper labial gingiva or palatal mucosa.

There have been several surveys of school-children to investigate the incidence of damaged incisors and to discover any predisposing factors, but as they all agree in their general conclusions it will suffice to quote from the two most recent surveys. McEwen, McHugh, and Hitchin (1967) conclude that increased overjet with proclination of upper incisors and lip incompetence are significant predisposing factors to fracture of upper central incisors. They found that proclined upper incisors are twice as vulnerable as those normally inclined and that incompetent lips more than double the risk; therefore when both conditions are present it would seem reasonable to expect that the risk would be even greater. However, this hazard should be seen in perspective as the incidence they give for fractured proclined incisors is 10 per cent, which is 5·2 per cent greater than that for normally inclined incisors, and 10·7 per cent of children with incompetent lips had fractures which is an increased incidence of 6·6 per cent compared with children with competent lips.

Gelbier (1967) found that the most vulnerable age range is from 8 to 11 years with 9 years as the peak incidence year, and a common finding is that boys are more than twice as likely as girls to damage their incisors. Gelbier also states that only 12 per cent of the injuries in his survey occurred during contact sports, so that the alternative of providing a mouth protector would appear to be of limited value.

To summarize then, the situation where very early preventive treatment should be considered is where the upper incisors are very exposed, that is, where they are proclined with an increased overjet and there is a lack of lip-cover, particularly if the child is a boy of about 9 years af age who is keen on contact sports or is accident prone, and especially if conditions are favourable for a stable result.

Psychological Disturbance

The appearance of these children may lead to teasing by their contemporaries or it may be a cause of concern for their parents. Some children become very self-conscious and they are often keen to accept early treatment, even when it is explained that a long period of retention may be necessary. However, before embarking on treatment it must first be established that the cause of concern is the prominence of the upper incisors and not some other feature, for example it may be the apparent large size of the upper incisors relative to a small face which will alter with future growth, or it may be the unsightly appearance of a fractured incisor or an upper median diastema. Unless the problem is solved following treatment, it will be hard to maintain enthusiasm should prolonged retention be required.

THE INCIDENTAL ADVANTAGES OF EARLY TREATMENT

Co-operation

The co-operation of the patient is often surprisingly good between 10 and 12 years of age provided enthusiasm for treatment exists or can be generated, as the child is not old enough to be over-concerned with the appearance of the appliance and is in the submissive age-group.

Schooling

The loss of time from school entailed through attending for treatment is not quite such a problem when the child is at junior school, and if prolonged retention should be found necessary, attendance is only required every 2 months or so in order to supervise the retainer and the developing occlusion, which can be combined with a dental inspection every other visit.

Also, when it is known that the child will be attending boarding school later, where it is often difficult to receive treatment during term time, the active treatment can be completed beforehand and future visits can be during half-term and terminal holidays until the permanent dentition is complete.

Active Treatment Time

With favourable cases the active treatment time is limited to the retraction of the incisors, so that the appliance is worn full-time for a shorter period as retention is maintained at night-time only. Occasionally 3|3 may need some alinement when they erupt, but even then they frequently require less movement than if treatment had been delayed. This can usually be anticipated before treatment is begun from the radiographs, when if they were too far out of position, especially if palatally placed, treatment should be deferred until they have erupted.

It is said that bone is more responsive in the younger child, and in fact the rate of tooth movement during early treatment has been found to be somewhat faster, since the rate of overjet reduction varies between 1·25 mm. per month and 2·5 mm. per month compared with the 1 mm. per

month commonly found in the early teens; the more rapid rate usually being associated with incisor spacing.

Angulation of 3|3

As 3|3 are not actively retracted, the removable appliance hazard of excessive mesial movement of their apices is avoided, although it could be argued that this might still happen because most of the change in their angulation occurs during the retraction of the incisors (*Figs.* 3F, 4C); the roots of 2|2 apparently guide the crowns of the unerupted canines distally, provided they are both close to the line of the arch. But as the whole tooth lies within bone and the crowns of 3|3 are moved through a smaller arc, any mesial movement of their apices should at least be reduced.

Anchorage Value of 6|6

The upper first permanent molars only have to withstand the retraction of the upper incisors, consequently there should be less likelihood of their forward movement so long as E|E are retained and better still D|D as well. In practice it has been found that there is no greater tendency for the anchorage to shift mesially during early treatment than when treating in the permanent dentition, although if E|E have been lost either the anchorage should be augmented with, for example, extra-oral anchorage or treatment should be deferred until the eruption of 5|5.

A further advantage is that provided 6|6 can be temporarily conserved, they can be used as anchorage for the reduction of the overjet prior to their loss, when this is necessitated through their poor condition, and the incisors can then be retained with an almost passive Andresen appliance. If possible the extraction of 6|6 should be delayed until 4|4 have erupted to avoid excessive mesial movement of unerupted 7|7, and so that extra-oral traction may be applied to 4|4 in order to open the upper canine spaces. When the crowding or the overjet is very severe, 4|4 may have to be removed in addition to 6|6 and in that case it is better to extract 4|4 first to allow 3|3 into the arch, and to delay the extraction of 6|6 until 7|7 have erupted, following which 5|5 are alined. The appliance in use also retains the retracted incisors and maintains the space for the unerupted teeth. In this way permanent cheek teeth are available at all times for clasping or banding, whereas normally the eruption of 7|7 has to be awaited before appliance therapy can be started.

THE POSSIBLE DISADVANTAGES OF EARLY TREATMENT

Age of the Patient

If treatment is begun very early for preventive reasons, the child may be too young to appreciate the reason for treatment, resulting in poor co-operation, and the very young patient is prone to be careless with the appliance, leading in some cases to frequent repairs, although this usually improves with lecturing. Also, their oral hygiene tends to be poorer than that of older children which must be seen to improve before appliance therapy is begun.

Incomplete Reduction of the Overjet

It is sometimes found that the overjet will not reduce any further and this is commonly due either to the induced crowding of the unerupted permanent teeth or to the depth of the overbite. If it is caused by the crowding, 4|4 can be enucleated and treatment continued provided the crowding or the overjet is not too severe; but where the overbite is excessive it can be difficult to reduce with simple appliances, and these cases are often better treated in the permanent dentition when a lower fixed appliance can be employed, and the overbite may become less severe with future growth as indeed may also the overjet (Björk, 1953). Rarely a persistent digit-sucking habit may interfere with the early retraction of the upper incisors, though normally this is ignored as the habit is frequently discontinued soon after the appliance has been inserted. The severest overjet that has been reduced to date was one of 15 mm. which was completely reduced to 4 mm., 4|4 being extracted on eruption near the end of active treatment.

Greater Tendency to relapse

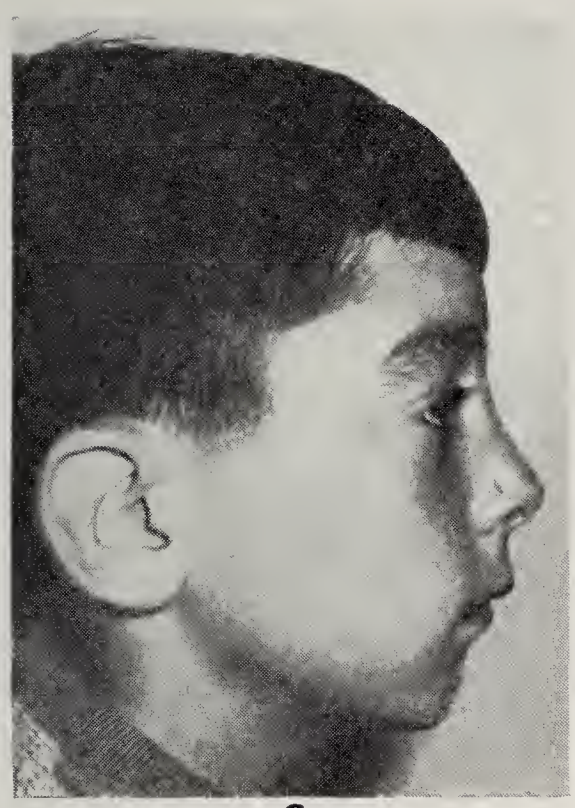
There is no doubt that cases treated very early are more liable to relapse than when treatment is delayed, and while this may be due to the incomplete reduction of the overjet, the crowding of the unerupted permanent teeth, or the effect of the erupting canines, it would appear that this is often caused by the immaturity of the soft tissues, which have been stated to mature at about 11 to 12 years of age (Ballard, 1960). This maturation may in part be due to a conscious effort to approximate mildly incompetent lips as the child becomes more appearance-conscious, but by treating very early, advantage is not taken of it. Therefore if the soft tissues are unfavourable for the stability of the retracted incisors, treatment is better deferred until 11 years of age which is usually the late mixed dentition stage, unless there are strong indications for very early treatment and lengthy retention is acceptable.

Length of Treatment

When prolonged retention is required following early mixed dentition therapy, the total treatment period can be 3 years or more and the total surgery time involved will be greater than for treatment in the permanent dentition, although much of it is just to supervise the retainer and the developing occlusion.

A

B



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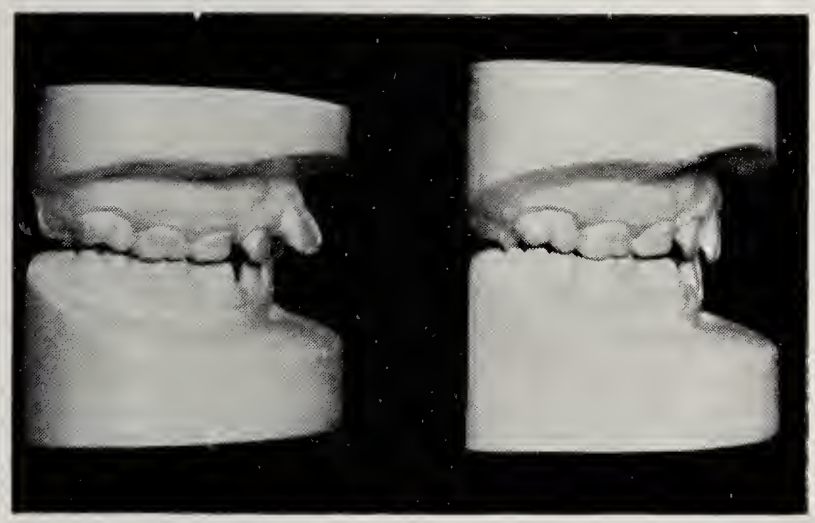
D



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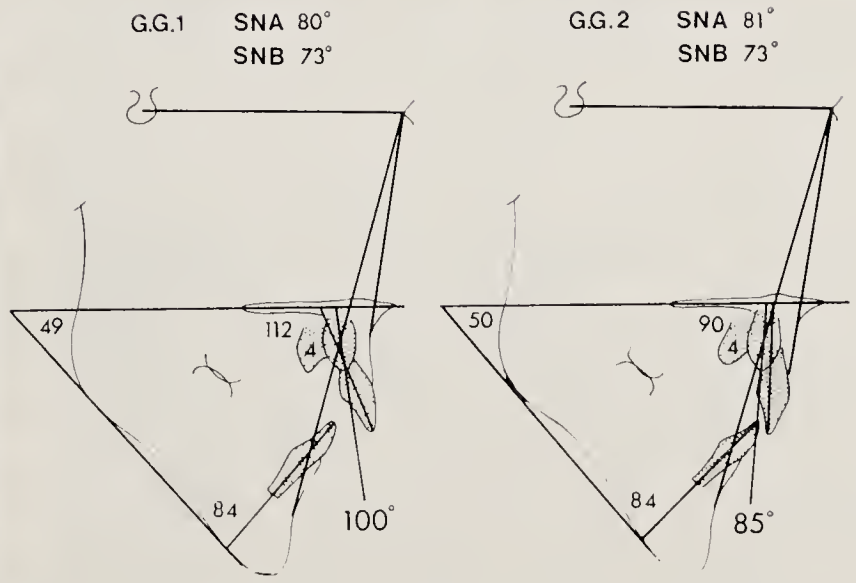
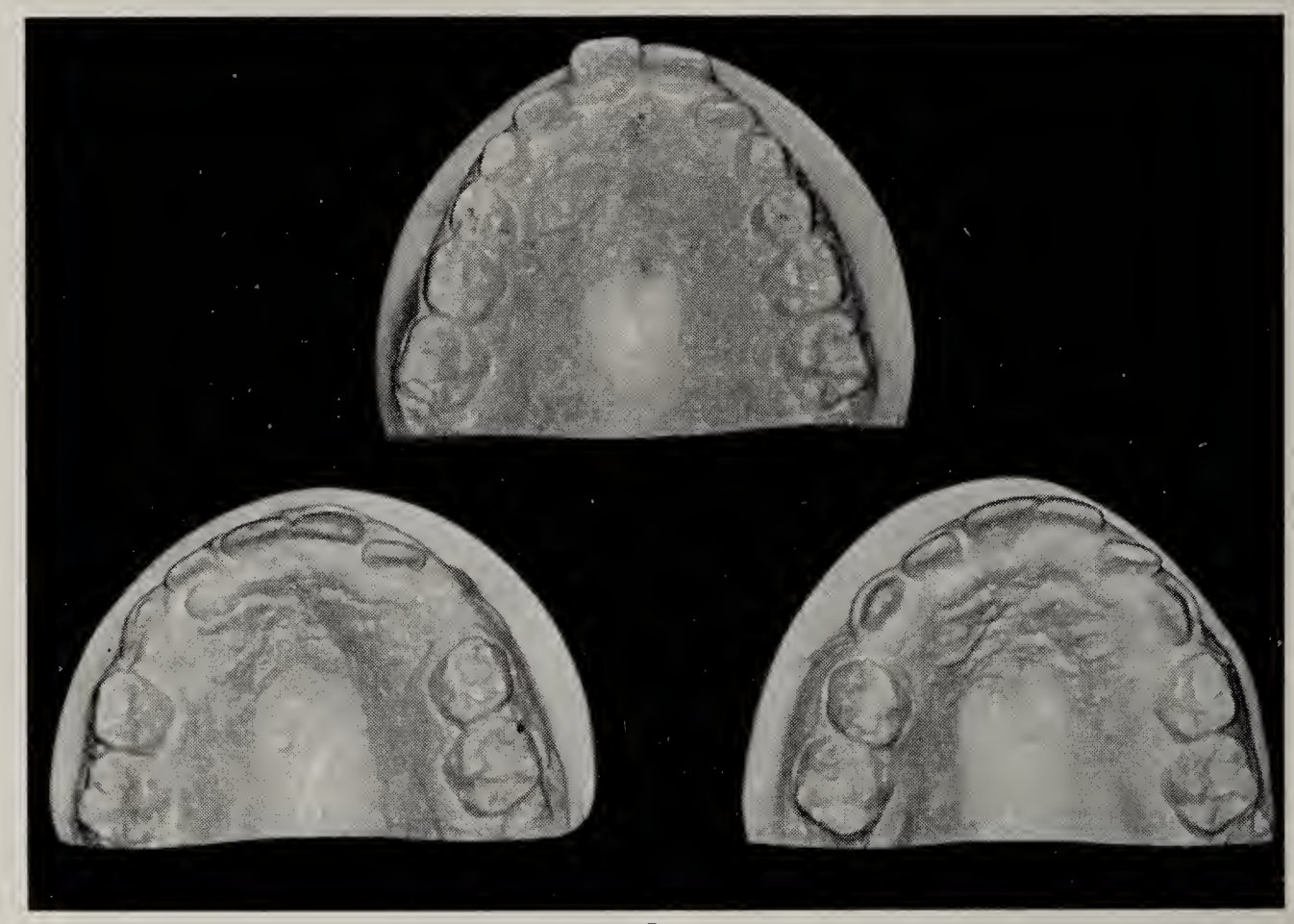


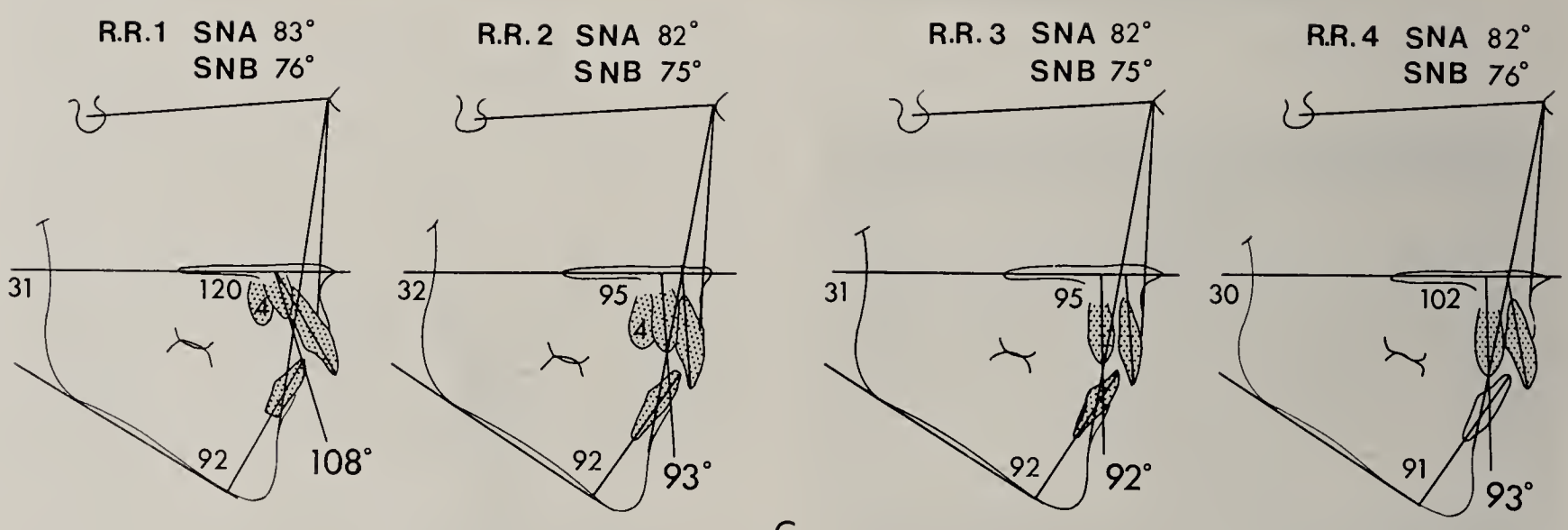
F

Fig. 3.—Records of G.G. (early mixed dentition therapy), aged 8 years 6 months at the beginning of treatment and aged 8 years 10 months on completion of active treatment. A–D, Photographs, before and after treatment. E, Right lateral view of the models, at the beginning and end of active treatment. F, Tracings of the lateral radiographs. Note the change in angulation of $\underline{3|3}$ during 4 months' active treatment.

A



B



C

Fig. 4.—Records of R.R. (late mixed dentition therapy), aged 10 years 1 month at the beginning of treatment and aged 11 years 1 month on completion of appliance therapy. A, Right lateral view of the models; before treatment, as $\underline{3|}$ erupted near the end of retention, and 7 months out of retention. B, Occlusal view of the upper models showing the eruption of $\underline{3|3}$ into the line of the arch. C, Tracings of the lateral radiographs; before treatment, after 6 months' active treatment, at the end of 6 months' retention, and 7 months out of retention. Note change in the angulation of $\underline{3|3}$ during active treatment.

However, when treatment is begun in the late mixed dentition, the total surgery time involved and the period of treatment are often not very different from that of permanent dentition therapy, and treatment is frequently completed within 2 years, although of course this is dependent upon the rate of eruption of 3|3.

Assessment of Crowding

The unpredictability of future growth together with the uncertain size of the unerupted upper premolars and canines makes the early assessment of the eventual degree of crowding difficult. Consequently it is advisable not to remove 4|4 too early, unless crowding is obviously preventing the overjet from being reduced any further or 3|3 are about to erupt with insufficient space present for them, and even then the general development of the child should be noted to gain some idea of the future growth potential.

Further Treatment required later

It has already been mentioned that 3|3 may occasionally require some alinement on eruption, but this can be easily accomplished by soldering buccal springs to the Adams clasps of the retainer when one is being worn.

If the lower arch is going to require appliance therapy later, treatment is best deferred until both arches can be treated together.

Damage to 2|2 by Unerupted 3|3

In theory there is the danger that the roots of 2|2 may be damaged by the unerupted upper canines during their retraction, but in practice no evidence of this has been found. Although when the upper incisors are vertical or 2|2 are rotated, necessitating fixed appliance therapy and apical movement, it is advisable to wait until 3|3 have erupted to eliminate this risk, and so that any other alinement found necessary may be completed with the same appliance.

CASE REPORTS

The following two cases illustrate the alternative timing of early treatment:—

Case 1

G.G. (*Fig.* 3; early mixed dentition therapy), when first examined had potentially competent lips with the lower lip trapped behind 21|12. The overbite was increased and complete on the palate, and crowding was present in both arches. Early treatment was undertaken because the appearance of the condition was causing psychological problems. He was aged 8 years 6 months at the beginning of treatment.

April, 1966: C|C were extracted to allow 2|2 to drift distally.

July, 1966: An upper removable appliance was inserted to reduce the 10 mm. overjet and the overbite.

November, 1966: After 4 months' active treatment the overjet was completely reduced to 4 mm. and nocturnal retention was begun, the patient then being aged 8 years 10 months. As the crowding was severe it was anticipated that retention would probably have to be continued until 4|4 were extracted and 3|3 had erupted, which was confirmed when an attempt was made to discontinue the retainer after 6 months.

January, 1968: 4|4 were extracted on eruption.

April, 1968: 3|3 were about to erupt. Retention will be discontinued when 3|3 have fully erupted.

Case 2

R.R. (*Fig.* 4; late mixed dentition therapy), when first examined had rather flaccid incompetent lips with a short upper lip. The overbite was increased and complete on the palate, and the upper arch was crowded. E|E had been lost and it was thought that the lower arch would probably also be crowded. The prognosis for the stability of a complete reduction of the overjet was assessed as doubtful, but early treatment was undertaken as he was rather accident prone, and |1 had already suffered a blow which had slightly chipped the incisal edge. At the beginning of treatment he was aged 10 years 1 month.

July, 1966: C|C were extracted.

August, 1966: An upper removable appliance was inserted to reduce the 10 mm. overjet and the overbite.

February, 1967: After 6 months' active treatment the overjet was completely reduced to 2 mm., 21|12 being over-retroclined, and nocturnal retention was begun.

April, 1967: 4|4 were enucleated as on palpation 3|3 could be felt close to eruption. The patient had recently suffered a fall which damaged his nose but not the retracted incisors!

June, 1967: 3| had started to erupt.

August, 1967: The retention was progressively discontinued after 6 months and by then |3 had started to erupt, the patient being aged 11 years 1 month.

March, 1968: 7 months out of retention; 3|3 eruption was almost complete and the upper incisors had uprighted with the overjet slightly increased to 3·5 mm. The residual spacing in the upper arch should close as 7|7 erupt, and the crowding of the lower arch will be assessed when the lower premolars have erupted.

SUMMARY OF CRITERIA FOR EARLY TREATMENT

Indications for Early Mixed Dentition Treatment

1. When 21|12 are very exposed, that is, they are proclined with an increased overjet and there is a lack of lip-cover, particularly if the child is a boy of about 9 years of age who is keen on contact sports or is accident prone, and especially if conditions are favourable for a stable result.
2. When the appearance of the condition is causing psychological problems, and prolonged retention will be acceptable if required.
3. Rarely in an attempt to improve the health of the upper labial gingiva or palatal mucosa.

Unfavourable Factors for Early Mixed Dentition Treatment

1. Unfavourable soft-tissue behaviour or morphology.
2. Excessive overbite.
3. Very severe overjet.
4. Severe crowding.

Any one of these features may prevent the incisors from being retracted into a stable position; consequently, unless there are strong indications for very early therapy, and lengthy retention will be acceptable should it be found necessary, treatment is better deferred until at least the late mixed dentition and in some cases treatment may be difficult even in the permanent dentition.

Contra-indications for Early Treatment

1. Poor co-operation and enthusiasm for treatment cannot be generated.
2. 3|3 more than slightly out of position, especially if palatally placed.
3. Hypoplasia or rotation of 3|3 or 5|5, when the upper arch is crowded.
4. 21|12 vertical or 2|2 rotated, necessitating fixed appliance therapy and apical movement.
5. Lower arch requiring appliance therapy later.
6. E|E lost, unless extra-oral anchorage will be tolerated or case is suitable for the Andresen appliance.

Late Mixed Dentition Treatment

Many cases can be treated at this stage so gaining most of the advantages of early treatment but avoiding or at least reducing some of its possible disadvantages. Treatment is completed at the time when normally it would just be starting, and active therapy can be commenced at a particular age without waiting until the permanent cheek teeth have erupted; the most favourable age range being from 10 to 12 years.

In addition to the indications already given for early mixed dentition therapy, it is of value in the following situations:—

1. 3|3 late in erupting.
2. Child is to attend boarding school in the near future.
3. 6|6 to be extracted because of their poor quality.

CONCLUSION

The early treatment of Angle's Class II, division 1 malocclusion is one of several debatable orthodontic measures, but from the experience gained in using this technique it is felt that there is a place for it in the orthodontist's armamentarium.

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DISCUSSION

Mr. J. H. Gardiner had often been assured by parents that schooling became more valuable as the children got older and parents very often made enquiries about treatment when their children were as young as 7 in case anything could be done.

He asked Mr. Fulstow if he had had any experience of the early extraction of unerupted first premolars in the treatment of these cases and the age at which he found it most beneficial to the distal drifting of the permanent upper canine teeth as these erupted.

Mr. Fulstow said that he preferred not to extract the upper first premolars too early because, with future growth, it was very difficult to estimate exactly how much crowding would be present, and, consequently, he preferred to extract the first premolars at the last possible moment, ideally just before the eruption of the upper canines. Usually, it did not involve the enucleation of the first premolars, but one could resort to this if it was found to be necessary. He would tend not to remove the first premolars too soon, otherwise one might be left with spacing later on, when further growth had taken place.

Dr. J. R. E. Mills did not agree with Mr. Fulstow, as Mr. Fulstow knew, but he thought that the points made were very important ones: The difficulty of getting older children away from their schools, the danger of trauma and perhaps, above all, the fact that if one saw an abnormality, logically one should put it right as soon as it developed. Yet the fact remained that probably the majority of the orthodontic profession preferred to treat their patients during the pubertal period. He thought that the primary reason was the length of treatment. Mr. Fulstow had given a picture of this, of prolonged retention and possibly a further period of treatment later on.

There were other reasons which were more nebulous and difficult to pinpoint. Mr. Fulstow had brought out the difficulty of reducing the overbite in the young child. There was a reason for this. During the pubertal period, the face grew a lot in vertical height. Often, advantage was taken of this in successful overbite reduction. If the treatment was carried out when the patient was younger, often the overbite was not reduced, and very often one got the upper teeth going back to some extent, and then the upper incisor pivoted about the lower incisal edge because

the overbite had not been reduced; the upper apex would come forward, as in both of Mr. Fulstow's cases. This was very difficult to sort out later on.

The other thing was that one could not relieve the crowding. One could not get the canines out of the way. He was interested in Mr. Fulstow's experience that the canines dropped back completely. Did he find that they always dropped back completely, or did they, in some cases, require retraction at a later stage during treatment?

Mr. Fulstow replied that this happened in only a small proportion of the cases, provided that when crowding was present, the first premolars were removed before the canines had erupted.

A NEW LOOK AT THE GROWTH AND DEVELOPMENT OF THE SKULL, JAWS, AND DENTAL ARCHES

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THE study of the development of the head, with special reference to the face, jaws, and teeth has long been recognized as an important and useful approach to the investigation of the development of the occlusion of the teeth, both normal and abnormal. A great deal of our understanding and teaching is based on the careful observation of the teeth of developing children as has been shown by Friel (1927) and of the heads and faces of groups of children as shown by Smyth and Young (1932).

A collection of dental casts is a permanent record of the growth and development of individual children or of groups of children, and head and jaw measurements and, more recently, cephalometric radiographs, record for future use the changing outlines of the growing craniofacial structures. To-day the dental cast and the cephalometric radiograph are regarded as the standard records for the study of the developing face and teeth.

THE UTILIZATION OF CASTS AND CEPHALOMETRIC FILMS IN GROWTH STUDY

The conventional method for using dental casts is to define a set of measurements of dental arch size and arrangements with special reference to spacing and crowding and the rotations of teeth. From such measurements, changes in tooth position and arch size from year to year can be assessed and an understanding gained of the way in which the dental arch is developing. Attempts have also been made to gauge the changes that take place in the maxillary teeth using the rugal markings in the palate as reference points.

Cephalometric films are used by means of the measurement of distances and angular relationships between points on the films which can be identified as known anatomical points or by constructing points geometrically.

Measurements of such features are made either directly on the film or else on tracings made of the films onto paper or plastic tracing film.

The selection of points either on the film itself or on tracings is always open to error and such errors are always assessed as part of whatever investigation is being undertaken.

One of the greatest problems in using cephalometric films is that of obtaining an area which can be regarded as stable enough to make measurements of growth changes in the face and jaws. The outlines of the sphenoid, basi-occipital, and ethmoid bones are used because as a rule, after birth, changes in these structures are relatively much smaller than those in the face, jaws, and teeth.

Even though the skull base does not change much in appearance on radiography from one year to the next, it is not always easy to choose precise points on two successive films or tracings which can be alined with one another with confidence.

A new method of comparison of films was developed by Björk (Lundström, 1960) in which two films to be compared are copied by the LogEtronic process whereby the films are made thin and light in density without any loss of detail contrast. Such film copies can be superimposed directly upon a viewing box and when adjusted, the similar areas about the sphenoid bone, basi-occipital bone, pterygomaxillary suture, and ethmoid bone can be exactly matched while areas in which changes have occurred such as the mandible, maxilla, and dental arches can be seen to have changed in size and position.

This method of direct superimposition makes it possible to match together the areas of reference in the skull base with more confidence than do the methods of measurement and tracing and it is an advance from the points of accuracy and speed once the thin copies are made or thin original films are routinely produced.

Presented at the Jubilee Meeting held on 11 May, 1968.

There is still, however, some confusion between superimposed films in areas of change which often makes comparison and measurement difficult and the method depends upon the films being very thin in density which it may not be easy to achieve as a matter of routine.

A NEW METHOD FOR COMPARISON OF CEPHALOMETRIC FILMS AND DENTAL CASTS

A new apparatus has recently been constructed for the comparison of objects up to a size of 12 in. × 10 in., either solid or transparent.

The apparatus is a modification of the blink microscope, devised by Pulfrich in 1904, as described in the *Encyclopaedia Britannica* (1957). The blink microscope is an apparatus for the comparison of star patterns taken on two photographic plates at an interval of time. The plates are illuminated from below and the areas to be compared are viewed through a single eyepiece, the two fields of view being superimposed by a mirror system. By blinking the light path from one plate to the other and back again, differences between the two plates immediately show up. Identical areas of course show no change.

The blink comparator for radiographs and dental casts works on the same principle, films are illuminated from below and dental casts from above (*Fig.* 1).

A refinement that has been introduced is that in the new equipment the light can be gradually faded from one object to the other; in this way changes from one stage to the next appear actually to be taking place. If a cine camera is placed over the eyepiece a film can be made of the sequence of changes in a growing face as seen in lateral cephalometric radiographs over a period of years and changes between individual stages of change can be studied by the ' blinking ' technique. Up to the present time only the upper dental cast has been studied, using the palatal markings as the area of registration between stages.

The advantages of the new method are that both solid and transparent material can be compared, the method of comparison is very rapid, and may be more accurate than methods used heretofore; original films can be used, however dense, as the light boxes are powerful and the light intensity is not cut down by superimposition of films and measurements of films can be made by laying marking points, transparent rulers and a protractor on the films, without permanently marking the films. The equipment can be used for research purposes over a mass of material or simply to make rapid clinical comparisons of pairs of films during treatment or over a period of observation of a developing malocclusion.

(The speaker then showed a cine film illustrating the growth and development of the faces and dentitions of a number of patients, over a period of 6 years, from 5 to 11 years of age. The cases illustrated the development of normal occlusion, the effects of early loss of a deciduous upper second molar, crowding of the permanent dental arch, Class II, division 1, and Class II, division 2 malocclusion, and double proclination of the incisor teeth.)

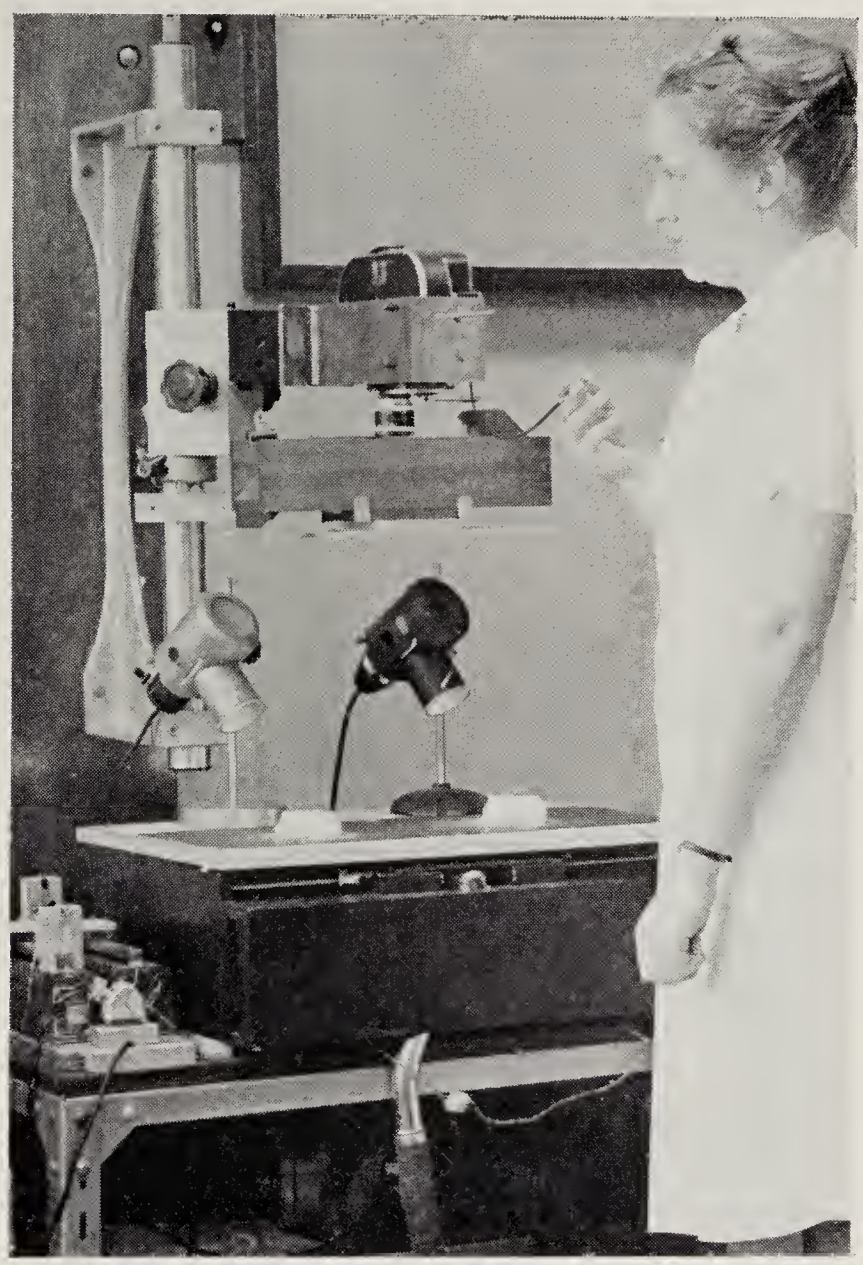

Fig. 1.—The blink comparator. The cine-camera is in position above, looking through the optical head which consists of a horizontal framework which contains, in the centre, the image-combining unit which receives light paths from mirrors placed at 45 degrees at right and left of the framework. Below can be seen the light box which is being used as a support for two dental casts which are illuminated independently by two focused microscope lamps. Below the table is placed a forced ventilation unit adapted from a cylindrical vacuum cleaner. The air jet is conducted to the light box and the viewing screens by a flexible hose. Ventilation is only required, of course, when the viewing boxes are in use. At the left of the table top are placed two rheostats, the controls of which are connected to permit dimming of one box while the illumination is raised in the other and vice versa. To the right of the box and out of sight is an automatic switch gear for blinking the lights on and off. (*Reproduced by courtesy of the 'American Journal of Orthodontics'.*)

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DISCUSSION

Professor B. C. Leighton asked if the apparatus had been made to Mr. Adams's specification for him, or was it a modification of the apparatus Mr. Adams had shown in the first place that was used for astronomy. Was there access to the subject being viewed at the time that it was being viewed? Mr. Adams said that he centred it on the rugae and the midline of the palate, which sounded very easy, but he could foresee difficulties unless one could get at the models at the time of viewing. He had the impression that the time interval from one radiograph to another could at times be misleading. The change in position, particularly of the upper central incisors, was so marked that it looked very much as though it had moved in a straight line from one position to the other, and he suspected that at times it might not do this. It seemed necessary to make reservations about the application of this to specimens where the time interval was perhaps a little too long.

Mr. Adams replied that the equipment had been made to his specification one evening on the kitchen table!

The operator had access to the models throughout and could put them where he wanted.

With regard to the validity of these results, what one found would depend in the first instance on the material one had. If one had a film every week, one was all right. If one had a film once a year, one had to make do with that. These films were taken at yearly intervals; he did not know of anyone who took growth study records more frequently.

Mr. L. H. Russell referred to the speed of the blink where the speed of the projection matched, and said that he felt that by using a faster taking speed with the same blinking speed and then projecting it through the camera at normal speed, one would see a less jerky effect and possibly smoother transition. It might help to know that on the market there was an ex-Government service stereo viewer for air photographs and in it there was a small plate with a dot which could be superimposed on the models. The two models could be put into the viewer and moved around as one liked. If you blinked alternate eyes, you would get the same effect.

Mr. Adams said that one had complete control over what one did. What he had done at first was to put on one light, shoot the camera, put on the other light, shoot the camera, but this was too slow so he allowed the instrument to do the blinking, and the result was that an occasional frame would come halfway between and give a flicker. Where blinking was concerned, there was a control to vary from once a second to ten times a second, and the speed with which one wanted to observe depended on how one felt. Some days, one wanted to see it faster; some days, slower. When making a film, one had to take it at a standard speed to get the exposure right. One could then show it at any speed one liked down to one frame per second.

Mr. Adams said he thought the transitions were perfectly smooth so the tooth appeared to move through the gum. Pulfrich had started with a stereo viewer and abandoned it in favour of a monocular viewer, because one wanted to see things exactly superimposed. A stereo viewer did not give the same effect.

Professor Ballard said that he had been fortunate enough to have seen these films in a completely darkened room and close up. From the back of the hall at least, the viewing did not do justice to the clarity of what could be seen in terms of growth and development in these cases. He thought that they had very valuable teaching as well as research purposes.

Mr. Adams said that this was quite true; the room was not fully darkened. Another point was that these films could be improved if they were made in a slightly different way. These films had been exposed and processed thirty feet at a time in the dark by the reversal method. Using the positive/negative method, he thought it would be possible to show a perfect cephalometric radiograph. Also, the picture was rather small and was seen better closer up.

Mr. J. D. Atherton thought that the material he had shown in the previous paper could be readily used in this way, but how small could one go in detail? Was it possible to photograph, for example, a single tooth? Could this be done with the apparatus or would it have to be modified in order to adapt it to almost microscopic proportions.

Mr. Adams said that, when viewing at first hand, one could see individual tooth movements perfectly clearly. If one wanted to make a film one could go down to within 7 or 8 in. of the material and then one could select a small area with the appropriate lens on the camera. In Mr. Adams' department they had dental casts at 6-monthly intervals and they found that they saw more in small tooth movements than in big ones.

TREATMENT BY THE BEGG TECHNIQUE IN THREE DIFFERENT TYPES OF MALOCCLUSION

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INTRODUCTION

THE Begg technique for the treatment of malocclusion was generally introduced some 12 years ago (Begg, 1956), but it is not commonly appreciated that at that time the method had undergone a 25-year period of development, and that its originator was then 58 years of age. As a postgraduate student, Begg studied orthodontics with E. H. Angle for two years, and gained considerable experience in the use of the edgewise appliance system in the non-extraction technique, which was then being practised. Several years later, however, he became dissatisfied with the long-term results achieved by this method. Hence the Begg technique is basically an attempt to overcome some of the problems which existed when edgewise arch therapy was introduced, and the method which has evolved is based upon the following principles:—

Orthodontic Extractions and Stone-age Man

Begg believed that failure to extract teeth in orthodontic treatment was the cause of relapse in many cases, and he therefore sought scientific evidence to support this hypothesis. This was obtained from a study of Australian Aborigine skulls, and as a result of his research, he was able to show that in primitive man, severe attrition took place at the proximal surfaces of adjacent teeth, as well as on their occlusal aspects. Consequently he postulated that ' attritional occlusion ' occurred throughout life and that this reduced the upper and lower arch lengths considerably. In stone-age man, therefore, impaction and other signs of crowding common to civilized man, were found to occur only occasionally. Begg therefore concluded that ' since the lengths of stone-age man's dental arches were continually reduced by tooth wear, orthodontists have a well-founded precedent—a scientific reason—for reducing dental arch lengths by tooth reduction ' (Begg, 1965).

Initial Tipping of Tooth Crowns into Final Positions

Begg considered that the edgewise appliance system was unnecessarily complicated as the method required the correction of apical positions before final crown alinement. The technique was also criticized on the grounds that the reaction from a ' tied-in ' archwire brought the whole dental arch into a more anterior position, and that in consequence of this, a period of anchorage preparation which necessitated the use of headgear and bite plates, was required in the initial stages of treatment.

As a result of clinical experiment, Begg discovered that the free tipping of tooth crowns was not possible with brackets as wide as those used in the edgewise technique as these rapidly permitted the archwire to bind in the bracket slot, and it was shown that an extremely narrow bracket was necessary in order to permit free movement of the teeth in any direction. Hence Begg subsequently used a modified type of Angle's ribbon arch bracket, as these permitted the teeth crowns to be tipped into their ultimate positions in the initial stage of treatment, before their roots were repositioned in the final stage.

The Use of Light Wires and the Principle of Differential Force

A further difference between the Begg technique and the edgewise appliance system relates to the magnitude of the forces employed. Thus in the former, a specially treated 0·016 in. (0·4 mm. approximately) round wire is used almost routinely and wires of either 0·014 or 0·012 in. (0·35 or 0·3 mm.) diameter are used for the initial correction of severely malalined arches. In contrast, the ' standard ' edgewise wire is 0·0215 × 0·028 in. in section, and this has approximately twice the cross-sectional area of the wire employed by Begg.

The use of differential force in the Begg technique is a further difference between this and the edgewise system. Briefly, it consists of the selective use of elastic forces in order to either move or stabilize teeth as required. A bilateral intermaxillary elastic force of 60–70 g. is used to tip the crowns of the maxillary incisors and canines rapidly towards their final positions. This force however does not produce a similar degree of mesial movement of the anchor molars. Conversely, if the elastic force is doubled, the anchor

Presented at the meeting held in Glasgow on 27 October, 1967.

molars are moved mesially, and the 6 anterior teeth are then relatively more stable. Although Begg based this aspect of his technique on clinical experience and observation, it was subsequently confirmed by Storey and Smith (1952). These authors studied the forces required to achieve bodily tooth movement by means of the edgewise appliance, and concluded that a force of 150–200 g. was required for the bodily retraction of a

Fig. 1.—Stage 1 setup with looped archwires. Note that canine ligatures are omitted if anterior teeth are crowded.

canine. It was also shown that within this range of force values the anchor molars remained stable. In contrast, it was found that a force exceeding 200 g. rendered the canines resistant to movement and that for bodily movement of a molar, a force of between 300 and 500 g. was required.

The above aspects of Begg orthodontic therapy have been emphasized in order to demonstrate how the technique differs from others in current use, and also to show that its successful application is not simply a matter of technical expertise. The Begg technique is now becoming more widely used in both America and Europe, and treatment results have been published by Brandt (1962), Brouwer (1963), Démogé (1965) and Booy (1966). No complete case reports of British children treated by this method have yet been reported, however, hence it is hoped that the results described here will be of interest.

METHOD

Begg (1961, 1965) describes the technique in three stages. These are related to the order in which the tooth movements are carried out; the basic procedures in a first premolar extraction case are as follows:—

Band-up and Attachments

a. First Permanent Molars

The bands on these teeth require a buccal tube, a buccal hook, and a lingual hook or button. The buccal tube must accept two 0·4-mm. wires with absolute freedom from binding, and the mesial aspect of the tube is directed slightly towards the gingival margin.

b. Incisors

Each incisor band has a Begg type bracket attached to the labial aspect with the slot directed gingivally.

c. Canines

The canine bands are provided with a bracket labially and a button or hook palatally.

d. Second Premolars

The bands for these teeth are prepared in the initial stages but they are not cemented until the treatment has progressed to Stage 2. A Begg arch bracket is fitted on the buccal aspect of these bands.

Sequence of Tooth Movement

Stage 1

In the first stage of treatment, rotated and malalined anterior teeth are corrected, and the molar and canine relationship is converted to either Class I or preferably slight Class III. In addition, the overbite and overjet are reduced so that an ' edge to edge ' incisor relationship is established.

Stage 2

In this stage, the residual extraction spaces are fully closed. Stage 2 is omitted, however, if the extraction sites have been fully utilized by overjet reduction and alinement of anterior teeth.

Stage 3

In the final stage, the roots of the anterior teeth are torqued palatally (or lingually) as required, and the second premolars and canines are uprighted and their roots paralleled.

Clinical Procedures

Stage 1 (*Fig.* 1)

The bands are cemented in position with the exception of those for the second premolars, and Stage 1 archwires are prepared and fitted (*Fig.* 2). These may be designed as either:—

a. Looped archwires with intermaxillary traction hooks and anchorage bends; or

b. Plain archwires with intermaxillary traction hooks and anchorage bends but no loops.

A looped archwire is only used if the degree of irregularity of the anterior teeth necessitates this course. It is subsequently changed to a plain archwire at the earliest possible opportunity.

Soft steel ligatures (0·1 mm.) may also be necessary from the commencement of treatment. These are applied from the intermaxillary hook to the archwire distal to the canine bracket, in all cases in which the anterior teeth are in good initial alinement. The purpose of these is to maintain the same relative positions of the anterior teeth within the arch; these ligatures are therefore omitted if incisor irregularities are present at the commencement of treatment. During the first and second stages of treatment,

the archwire extending beyond the buccal tube must be examined routinely and reduced as necessary, as this may impact against the second molar and retard progress. In Class I and Class II

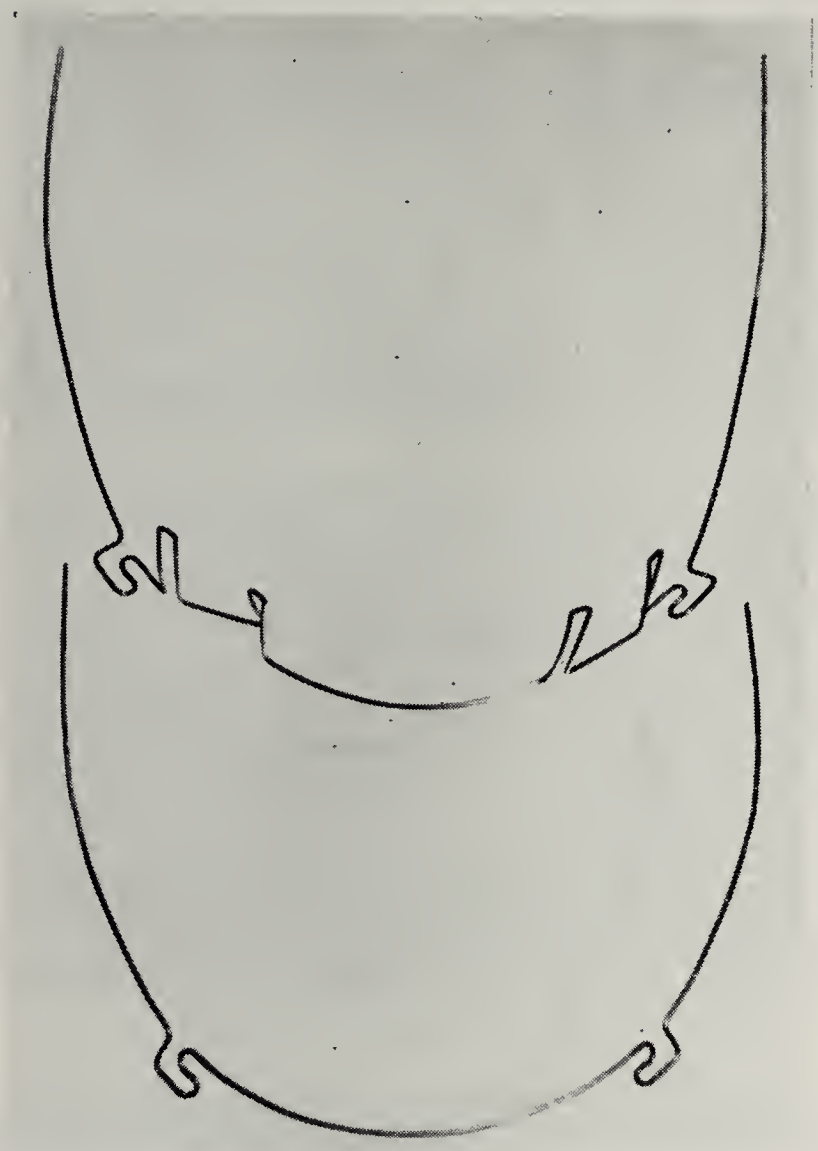


Fig. 2.—Looped maxillary archwire for correction of mesiolabial rotation of $\underline{2}|$, and distolingual rotation of $|\underline{2}$. A plain mandibular archwire is also illustrated.

cases, Class II intermaxillary latex elastics must be worn continuously and changed weekly or more often if breakages occur; freshly placed elastics should exert a force of 60–90 g. on each side.

Stage 2

This stage of treatment is only indicated if some of the extraction space still remains after the tooth movements relative to Stage 1 have been completed. The same archwires are used, and Class II traction is continued. In addition, residual spaces are closed by intramaxillary elastics extending from the intermaxillary traction hook to the distal end of the archwire in each quadrant. At this stage, the second premolars are banded and loosely ligatured to the archwires. These teeth however, are not firmly secured to the archwires until the final stages of space closure are reached.

Stage 3

Methods of carrying out Stage 3 have been described by Begg (1965) and Brandt (1962). The latter is described here and it differs from Begg's own method with respect to both the design of the torquing archwire and the time when root paralleling is started. Whichever method is

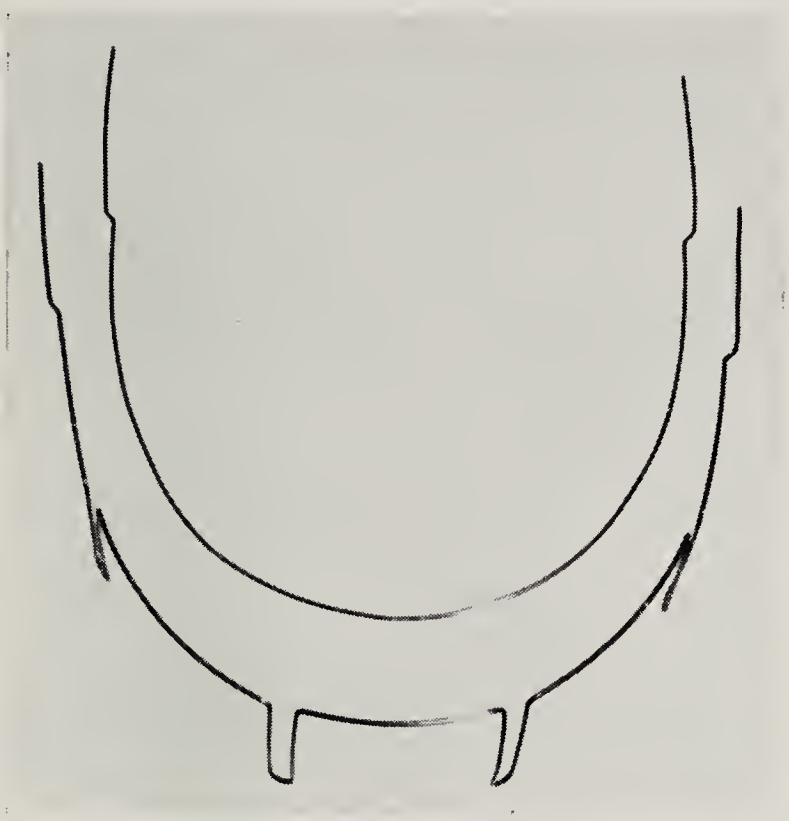


Fig. 3 —Stage 3 mandibular archwires.

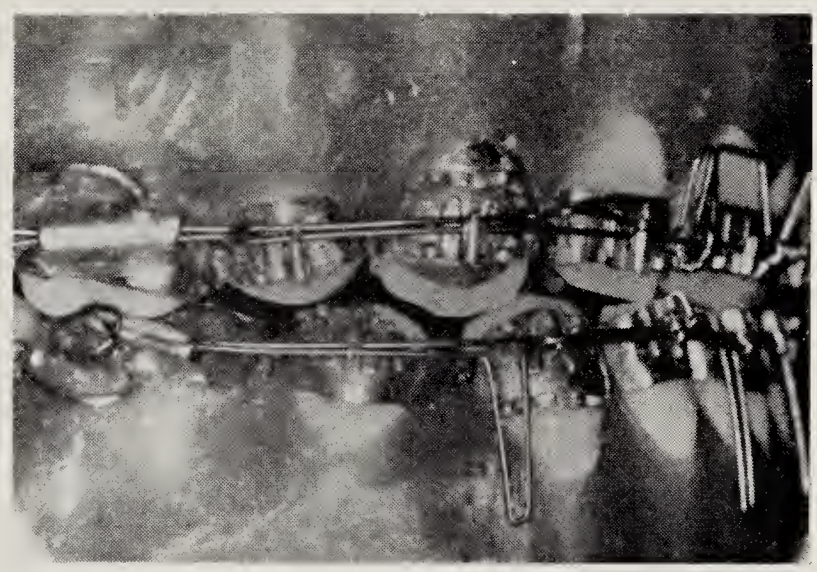


Fig. 4.—Stage 3 archwires before insertion of root springs.

adopted however, Stage 3 is not commenced until the following tooth movements have occurred:—

a. All rotations and malalinements have been corrected.
b. The incisors are in ' edge to edge ' relationship.
c. All extraction spaces have been closed.

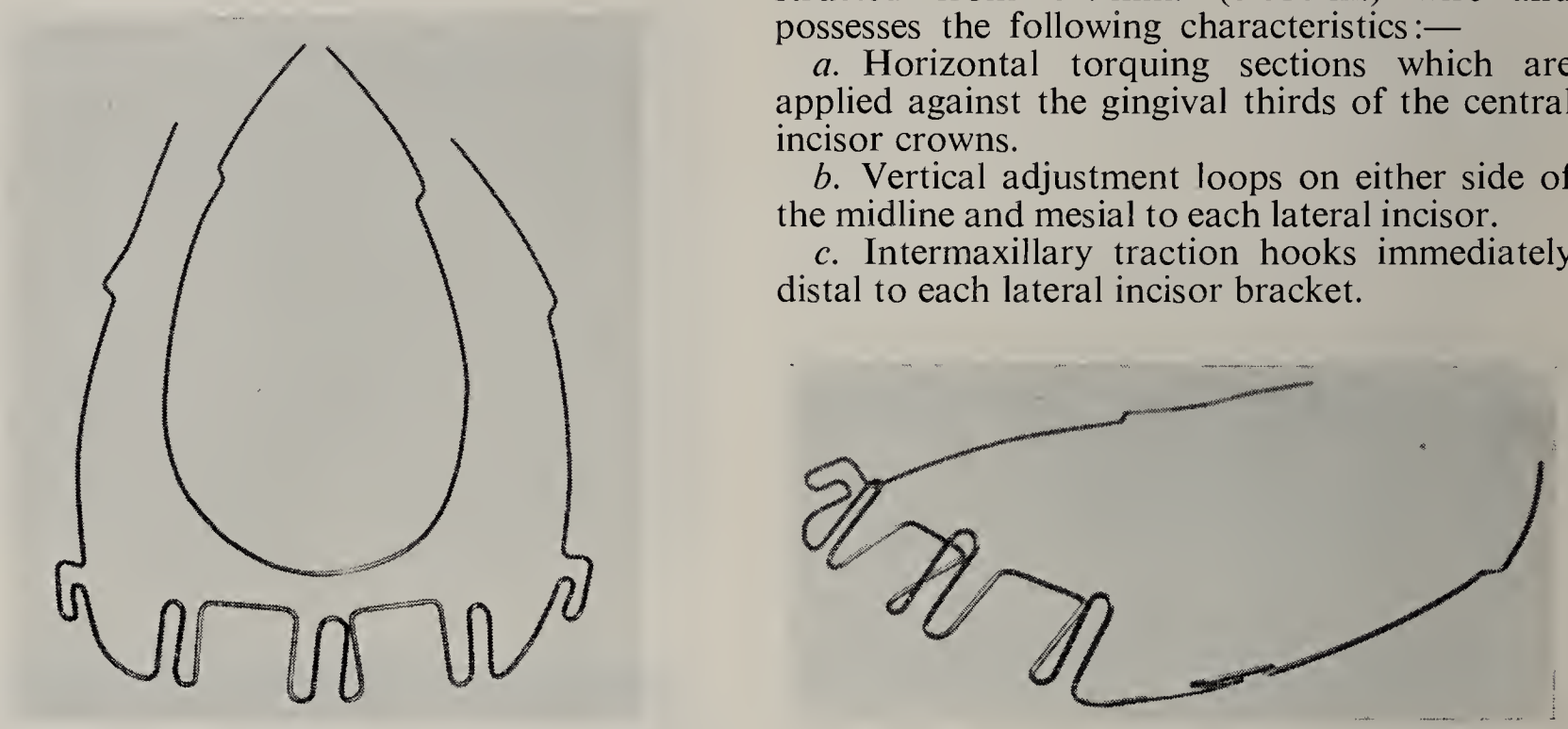
The procedures are as follows:—

Mandibular arch (*Fig.* 3)

The existing Stage 2 archwire is removed and replaced by a plain archwire, which is carefully shaped to maintain good arch form. An accessory (anti-space opening) archwire is also prepared and inserted gingival to the new base archwire. Both archwires are similar in shape and size and the main feature of the accessory one is that contraction loops are incorporated distal to the

brackets of the central incisor and canine bands. After fitting the archwires, the contraction loops are slightly activated and the free distal ends of the archwires are turned mesially outside the buccal tubes to maintain the space closure.

The effect of inserting the double archwire into all banded teeth is to achieve final levelling of the occlusal planes and for this reason the root paralleling springs are not inserted until a later visit.



A B

Fig. 5.—A, Plan view of Brandt base and torquing archwire. B, Side view of torquing archwire demonstrating inclination of anterior sections.

Fig. 6.—Insertion of root spring. Soft ligature is not tightened until spring is inserted. Another ligature may then be used to engage spring hook on to archwire.

Maxillary arch (*Figs.* 4, 5)

The basal archwire and Brandt torquing archwire are constructed as follows:—

Basal Archwire

This is a plain 0·4-mm. archwire which has neither intermaxillary hooks nor anchorage bends. It is shaped to fit well inside the curve of the palatal aspects of the anterior teeth, and when passive, the free distal ends converge towards the midline of the palate in the molar region; also bayonet bends are incorporated distally to the premolar brackets. The function of this archwire is to counteract the buccal movement of the premolars and molars, which would otherwise occur as a reaction from the torquing procedure.

Torquing Arch

The Brandt type torquing archwire is constructed from 0·4-mm. (0·016-in.) wire and possesses the following characteristics:—

a. Horizontal torquing sections which are applied against the gingival thirds of the central incisor crowns.

b. Vertical adjustment loops on either side of the midline and mesial to each lateral incisor.

c. Intermaxillary traction hooks immediately distal to each lateral incisor bracket.

d. Bayonet bends distal to each premolar bracket. The basal archwire is placed first and secured in the central incisor brackets. The torquing archwire is then positioned and the two archwires are inserted simultaneously into the remaining brackets (i.e., lateral incisors, canines, and premolars). The free ends of each archwire are then turned mesially from the distal ends of the buccal tubes in order to fully maintain space closure.

Insertion of Root Springs (*Fig.* 6)

In each quadrant, the archwires are freed from the premolar and canine brackets and soft steel ligatures are passed through the lockpin channels. The springs are then inserted and bracket engagement of the archwire is maintained by the spring coils. The retention arm of the spring is then turned through 180 degrees and any excess is removed. The soft steel ligatures are subsequently tightened before the spring is hooked over the archwires.

Adjustment of Torquing Arch

The degree of torque applied to the maxillary incisors is determined by the tension within the torquing archwire. This is increased as necessary by pulling more of the torquing archwire distally through the buccal tubes after first freeing the archwires.

Fig. 7.—*Case* 1. Clinical and cephalometric appearances before treatment.

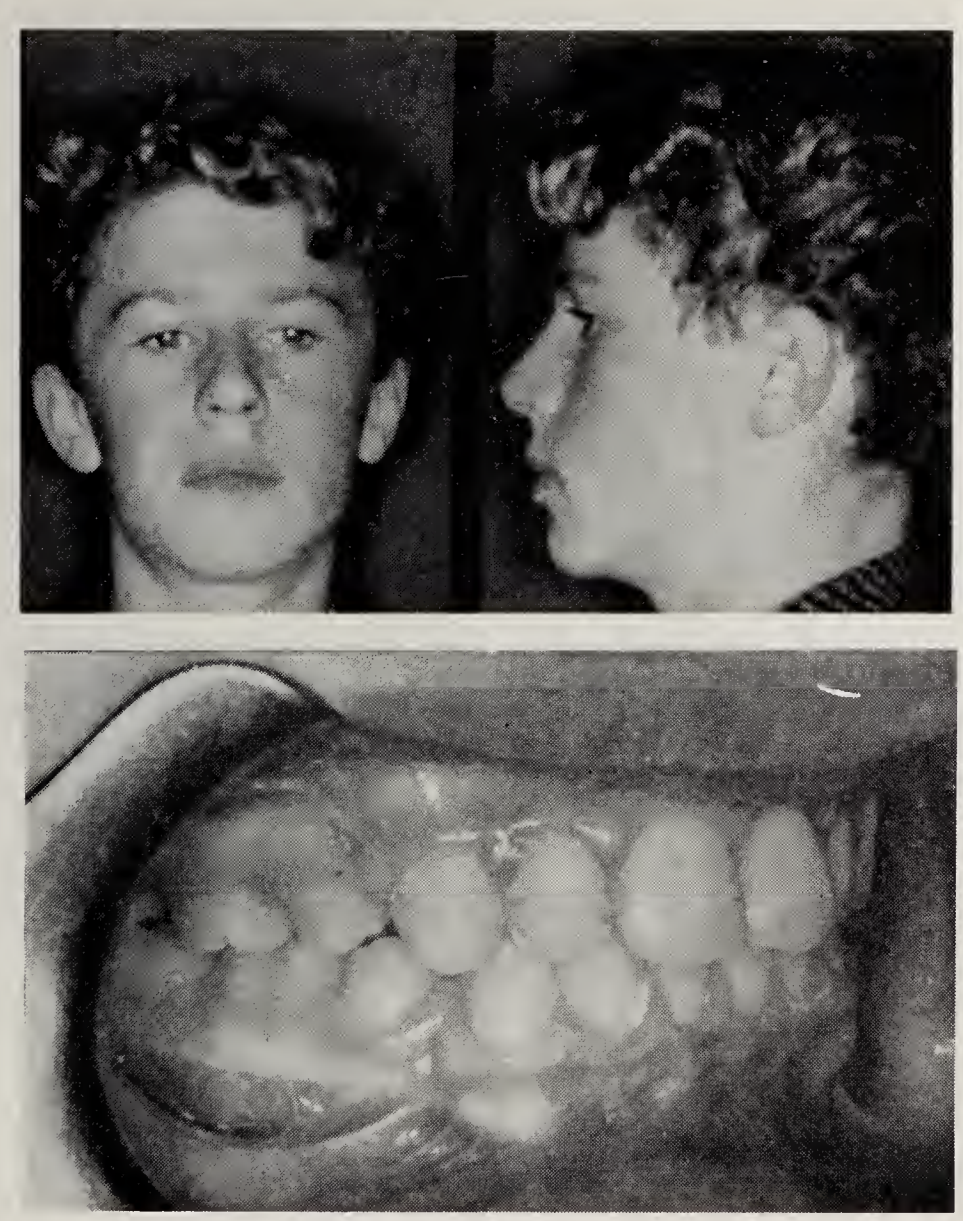


Fig. 8.—*Case* 1. Clinical and cephalometric appearances after treatment.

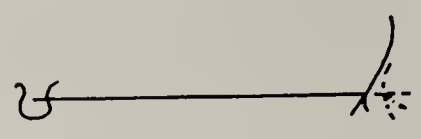
CASE REPORTS

Case 1

D.B. (male), treatment commenced at age 11 years 9 months.

Clinical Features (*Fig.* 7)

Overjet 9 mm., overbite 8 mm., close bite, bimaxillary crowding, centre lines normal and coincident, canine relationship Class I. *Fig.* 7 shows that the crown-root axis of the maxillary central incisors was abnormal and the cephalometric findings are shown in *Table I.*



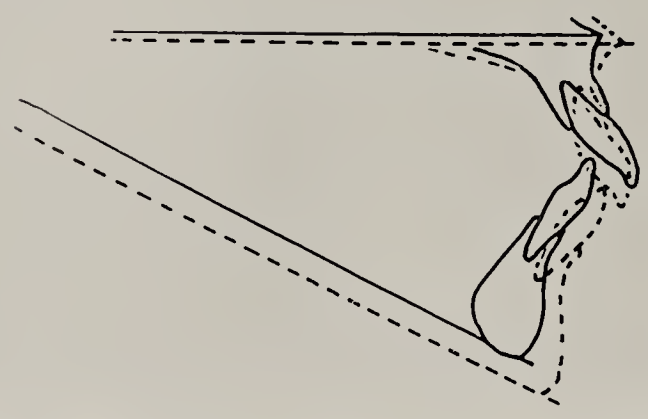


Fig. 9.—*Case* 1. Pre- and post-treatment cephalometric X-ray tracings superimposed on SN plane and registered at S.

Table I.—*Case* 1. Comparison of Pre- and Post-treatment Cephalometric Findings

Angle	Pre-treatment	Post-treatment
SNA	83·5°	84·0°
SNB	80·0°	80·0°
ANB	+3·5°	+4·0°
Maxillary-mandibular-plane angle	28·0°	27·0°
Maxillary central incisor axis relative to maxillary plane	127·0°	118·5°
Mandibular central incisor axis relative to mandibular plane	94·0°	103·0°

Aim of Treatment

To improve incisor angulations and reduce the tooth-tissue ratio, overbite, and overjet to normal proportions, and close all residual extraction spaces.

Treatment Record

February, 1966—first premolars extracted.
March, 1966—Stage 1 Begg treatment commenced (looped Stage 1 archwire used initially).
July, 1966—plain maxillary archwire inserted.
August, 1966—plain mandibular archwire inserted and Stage 2 commenced.
October, 1966—Stage 3 commenced.
May, 1967—Appliances removed. Treatment completed (*Fig.* 8).
Treatment time—16 months.

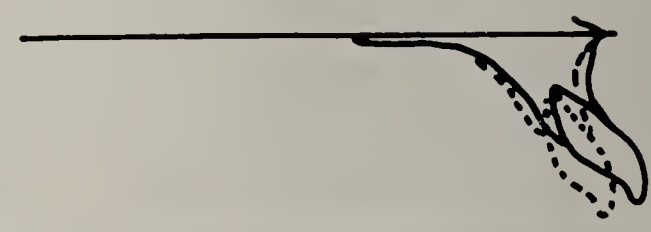


Fig. 10.—*Case* 1. Pre- and post-treatment cephalometric X-ray tracings superimposed on maxillary plane and registered at ANS.

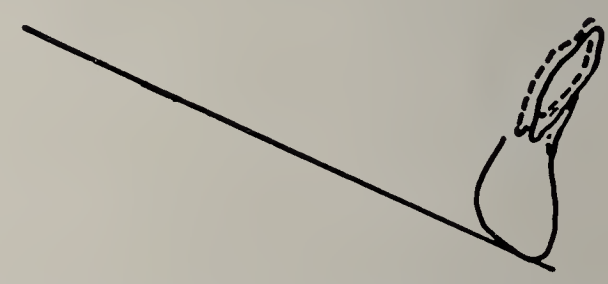


Fig. 11.—*Case* 1. Pre- and post-treatment cephalometric X-ray tracings superimposed on mandibular plane and labial cortical plate.

Analysis of Incisal Changes

Fig. 9 shows that some growth of the face occurred during the treatment period, and that the mandibular vertical growth slightly exceeded that of the maxillary complex. It can also be seen that no excessive labial movement of the maxillary central incisor apices occurred during treatment and that the degree of overjet reduction was considerable in spite of the adverse axial morphology of the maxillary central incisors. One other feature of interest is that the lower incisor apices are more lingual relative to the labial cortical plate, following treatment.

Fig. 10 demonstrates that the final positions of the maxillary central incisor apices are relatively unchanged, and that some slight re-contouring of the alveolar process has occurred.

The tracings in *Fig.* 11 confirm that the mandibular incisor apices are more lingually placed relative to their pretreatment positions, and that this change is associated with both apical and crown movement.

Case 2

L.D. (female), aged 10 years 3 months at commencement of treatment.

Clinical Features (*Fig.* 12)

Extreme skeletal Class II relationship and Class II, division 1 malocclusion. Overbite 4 mm., overjet 7 mm., close bite, bimaxillary crowding, and bimaxillary protrusion; pseudo Class I molar occlusion, due to mesial drift of lower buccal segments. There is also incompatibility of mandibular and maxillary

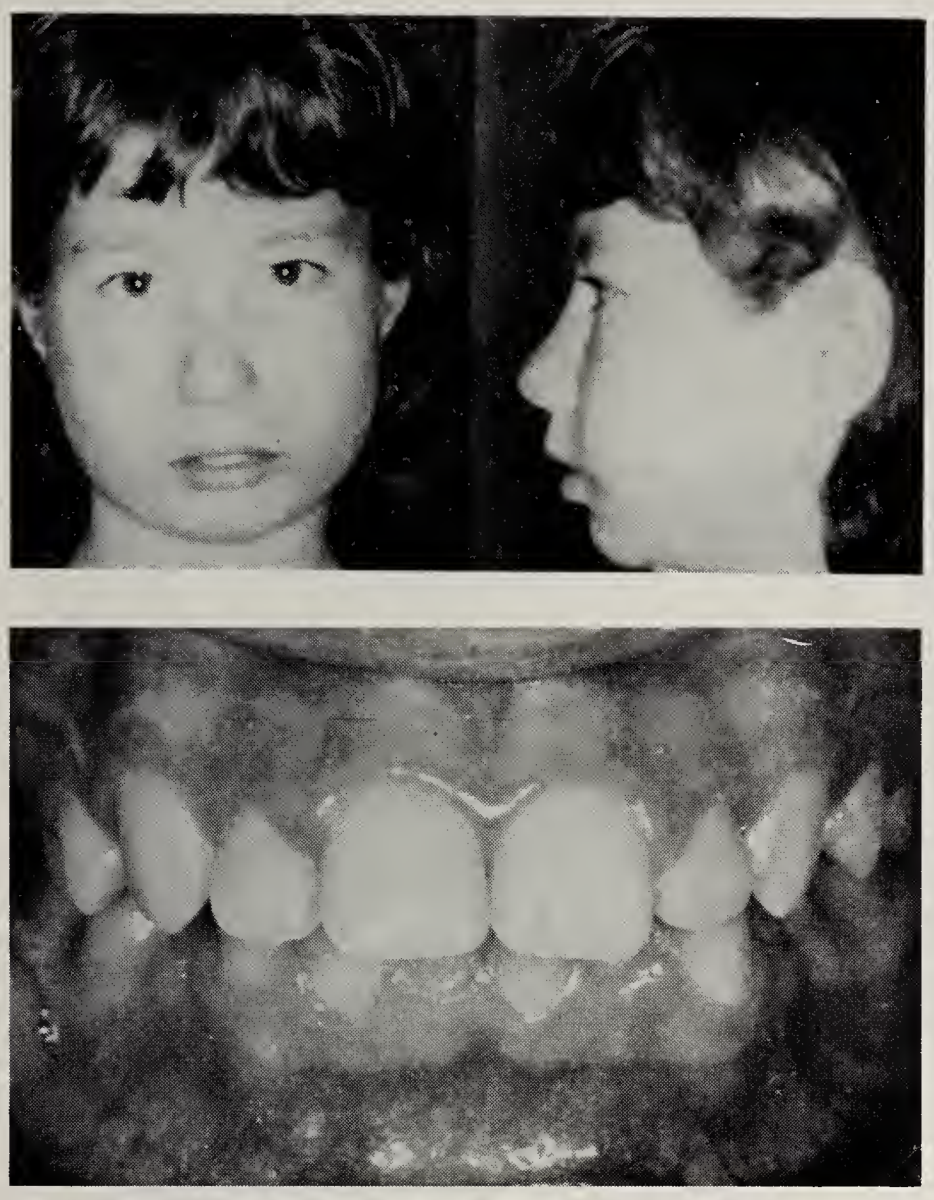


Fig. 12.—*Case* 2. Clinical and cephalometric appearances before treatment.

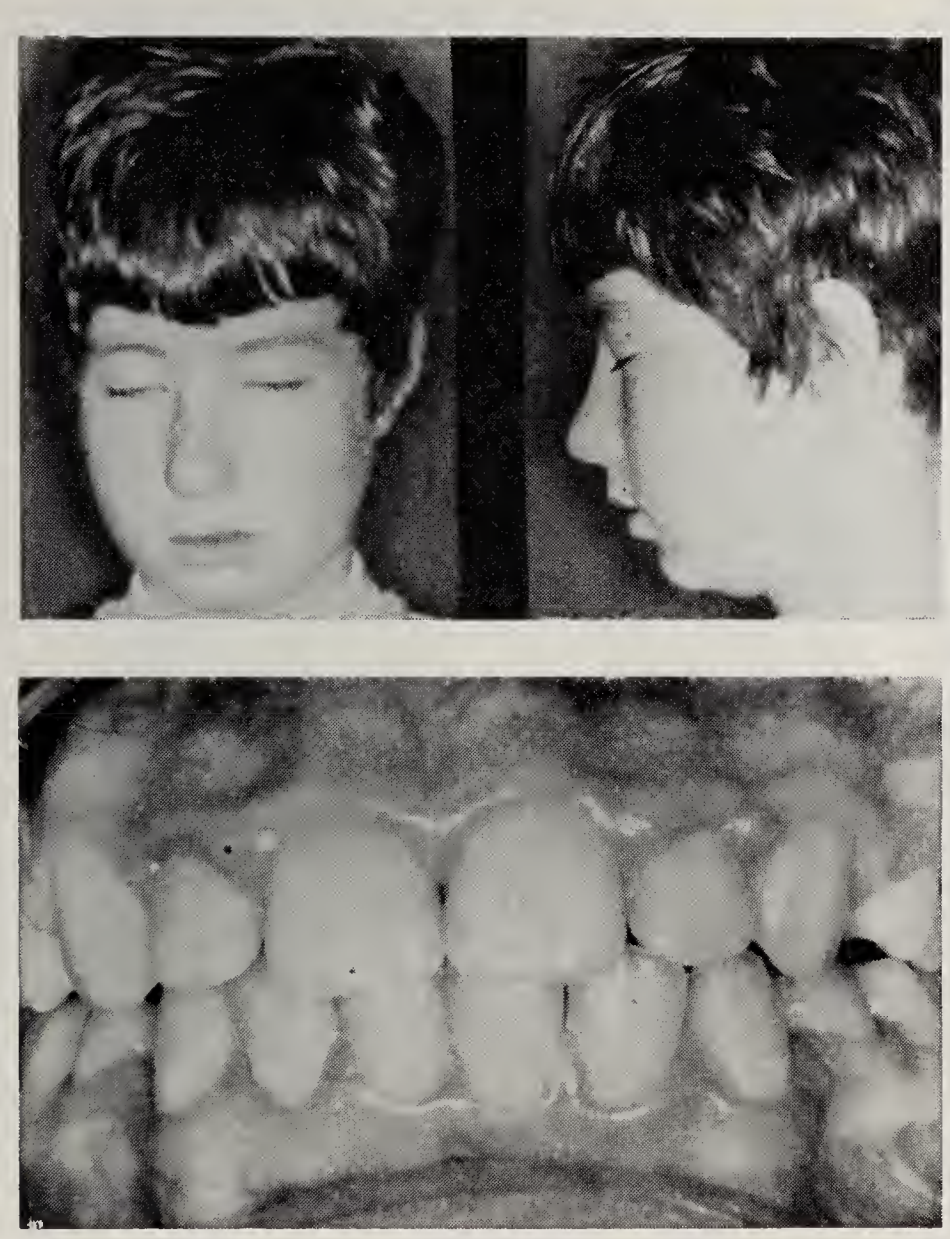


Fig. 13.—*Case* 2. Clinical and cephalometric appearances after treatment.

arches. The cephalometric findings are shown in *Table II.*

Aim of Treatment

To improve the axial inclinations of the incisors, and reduce the overbite, overjet, and tooth-tissue ratio to normal proportions and improve occlusal function. Residual extraction spaces will also be closed.

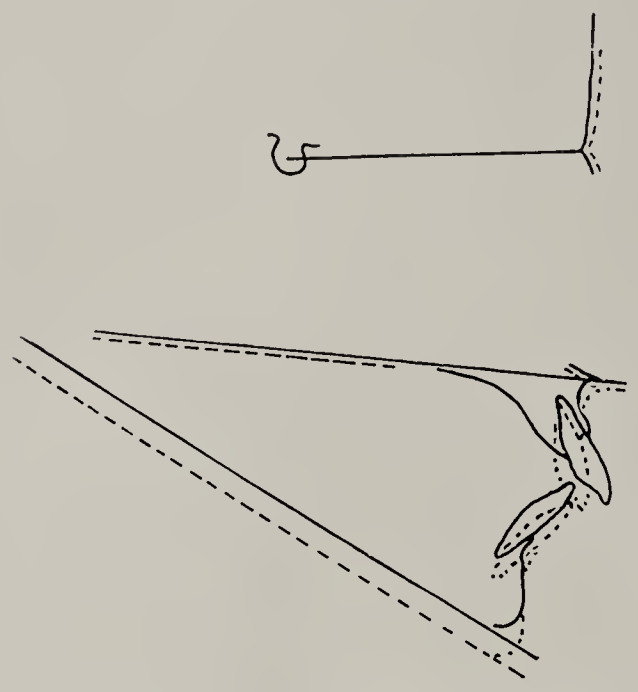


Fig. 14.—*Case* 2. Pre- and post-treatment cephalometric X-ray tracings superimposed on SN plane and registered at S.

Table II.—Case 2. Comparison of Pre- and Post-treatment Cephalometric Findings

Angle	Pre-treatment	Post-treatment
SNA	89·5°	87·0°
SNB	80·5°	79·0°
ANB	+9·0°	+8·0°
Maxillary-mandibular-plane angle	25·0°	26·0°
Maxillary central incisor axis relative to maxillary plane	117·5°	106·0°
Mandibular central incisor axis relative to mandibular plane	104·5°	104·0°

Treatment Record

April, 1966—first premolars extracted.
May, 1966—Stage 1 commenced (looped type mandibular archwire, plain maxillary archwire).
October, 1966—Stage 2 commenced.
February, 1967—Stage 3 archwires commenced.
September, 1967—appliances removed (*Fig.* 13).
Treatment time—18 months.

Analysis of Incisal Changes

Fig. 14 shows that during the treatment period there was only slight growth of the maxillary complex in both the vertical and horizontal planes. In contrast, it can be seen that although forward growth of the mandible was only slight, there was a considerable amount of change in the vertical plane. At the completion of treatment, the maxillary central incisors were positioned more lingually relative to their pretreatment locations and some recontouring of the alveolar processes may also be seen.

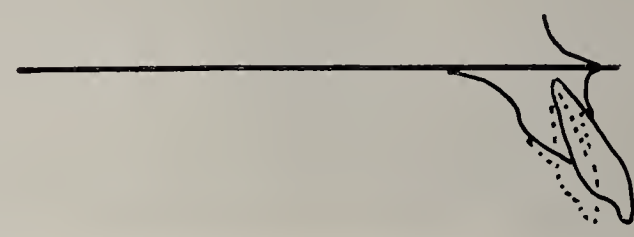


Fig. 15.—*Case* 2. Pre- and post-treatment cephalometric X-ray tracings superimposed on maxillary plane and registered at ANS.

Fig. 16.—*Case* 2. Pre- and post-treatment cephalometric X-ray tracings superimposed on mandibular plane and anterior cortical plate.

Table III.—Case 3. Comparison of Pre- and Post-treatment Cephalometric Findings

Angle	Pre-treatment	Post-treatment
SNA	84·5°	84·0°
SNB	77·0°	77·0°
ANB	+7·5°	+7·0°
Maxillary-mandibular-plane angle	16·0°	16·0°
Maxillary central incisor axis relative to maxillary plane	86·5°	100·0°
Mandibular central incisor axis relative to mandibular plane	98·0°	111·0°

The diagram (*Fig.* 15) demonstrates that the apices of the maxillary central incisors have not moved labially during treatment and that considerable palatal movement of the roots has occurred.

A marked degree of lingual movement of the lower incisor apices is seen in *Fig.* 16. This is particularly interesting since the counter effect due to forward mandibular growth is virtually absent (*Fig.* 14). It would seem therefore, that these changes are due to the combined effects of vertical mandibular growth and orthodontic treatment.

Case 3

D.L. (female), aged 17 years 7 months at commencement of treatment.

Clinical Features (*Figs.* 17, 18A)

Overbite 7 mm., overjet 2 mm., extreme close bite, maxillary crowding, Angle Class II molar relationship. Class II, division 2 incisor pattern and facial appearance. The cephalometric findings are shown in *Table III.*

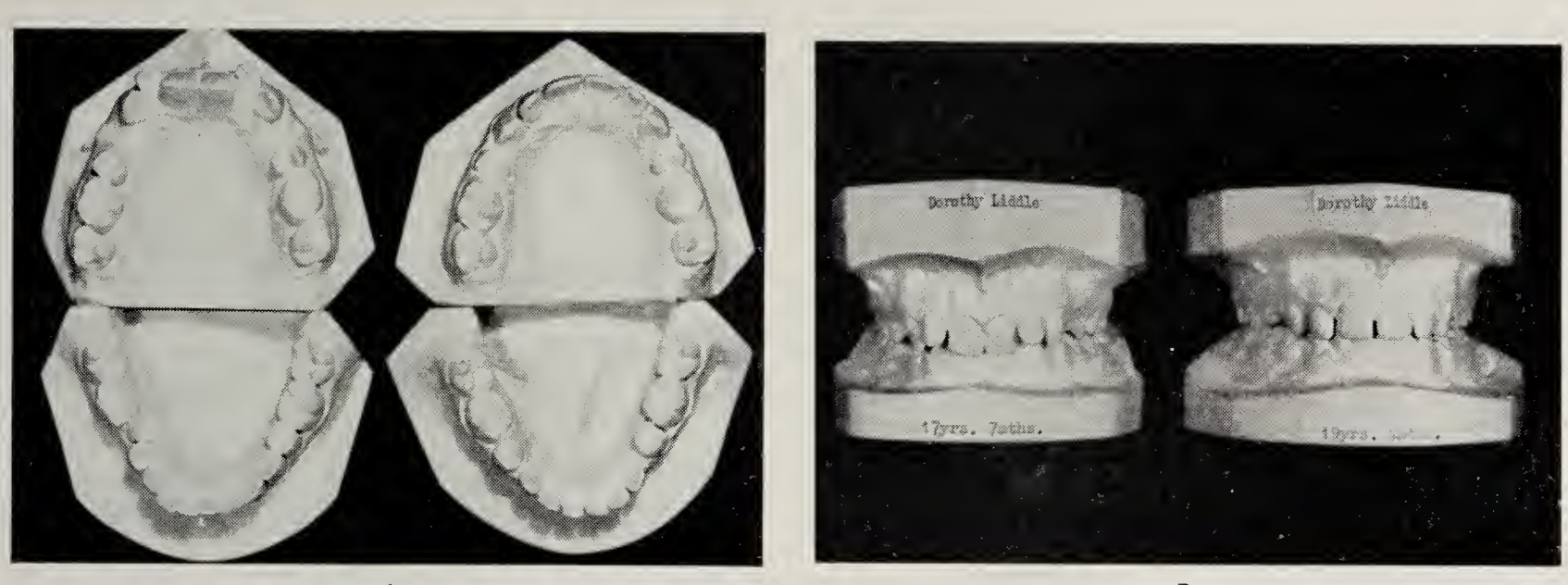
Aim of Treatment

To reduce the excessive overbite and the maxillary tooth-tissue ratio to normal proportions and restore normal maxillary incisor angulation.

Treatment Record

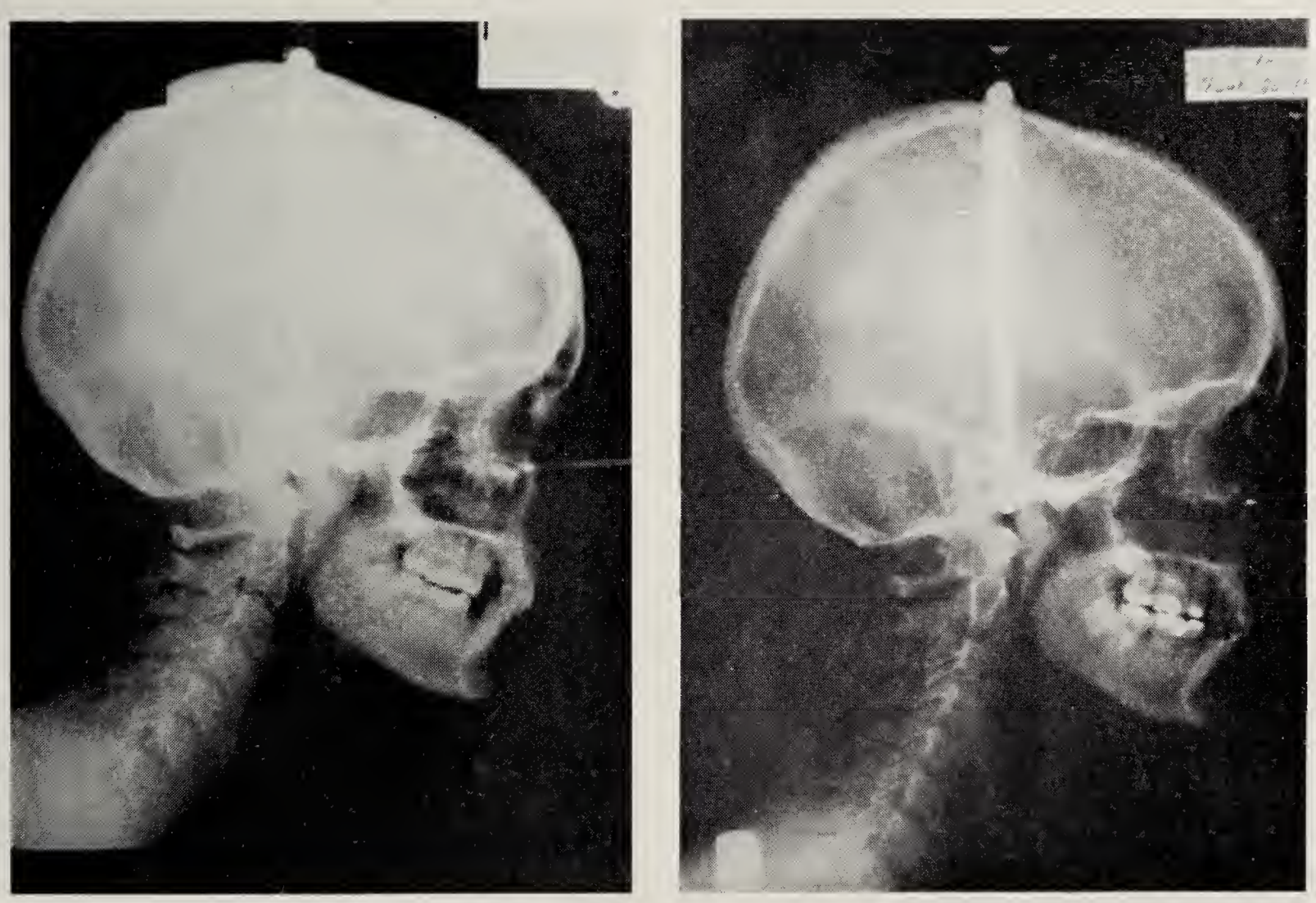
January, 1966—first premolars extracted.

March, 1966—Stage 1 archwires commenced (looped maxillary archwire for alinement of $\underline{2|2}$; plain mandibular archwire).



A B

Fig. 17.—Plan and anterior views of models of *Case* 3.



A B

Fig. 18.—*Case* 3. A, Before treatment. Note extreme labial displacement of maxillary central incisors. B, After treatment. Note improved axial inclination of maxillary central incisors and proclination of mandibular incisors.

May, 1966—plain maxillary archwire fitted.
June, 1966—Stage 2 commenced.
November, 1966—Stage 3 commenced.
September, 1967—appliances removed (*Figs.* 17, 18B).
Treatment time—21 months.

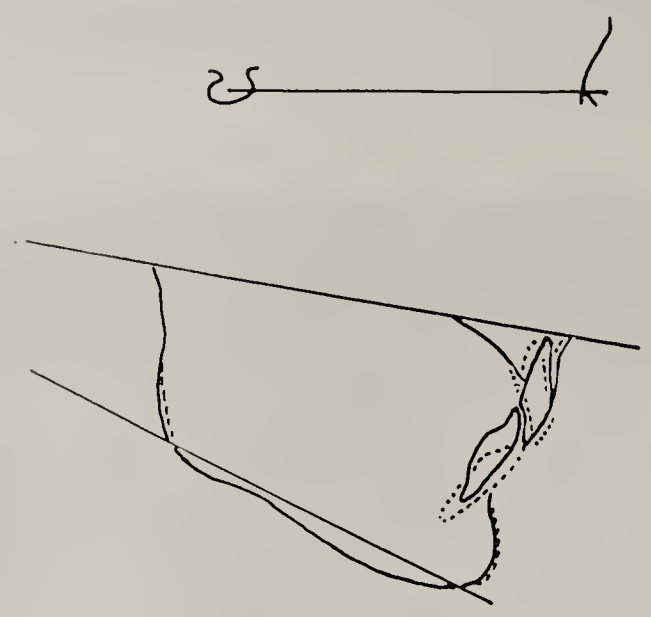


Fig. 19.—*Case* 3. Pre- and post-treatment cephalometric X-ray tracings superimposed on SN plane and registered at S. Note almost complete absence of growth.

Analysis of Incisal Changes

Fig. 19 shows that only very slight facial growth occurred during the treatment period and hence it may be concluded that the changes in the incisor relationship are almost entirely the result of orthodontic treatment. It can be seen that at the completion of treatment both the maxillary and mandibular central incisor apices are more lingually placed; an obvious proclination of the lower incisors is also evident.

Fig. 20 illustrates the axial changes undergone by the maxillary central incisors. The apices of these teeth are more palatal and they are also less superficially placed, relative to their pretreatment positions.

Fig. 21 demonstrates that mandibular growth had virtually ceased by the time treatment was commenced. It can also be seen that the degree of lingual movement of the mandibular incisor apices has been considerable and that a marked change in the axial inclination of these teeth has been achieved with very little labial movement of the crowns.

SUMMARY

The development and theory of the Begg technique, together with an outline of the clinical procedures has been described. The results of treatment and the observed cephalometric changes in three widely different types of malocclusion have also been shown.

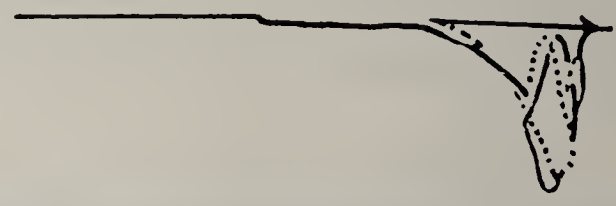


Fig. 20.—*Case* 3. Pre- and post-treatment cephalometric X-ray tracings superimposed on maxillary plane and registered at ANS.

Fig. 21.—*Case* 3. Pre- and post-treatment cephalometric X-ray tracings superimposed on mandibular plane and anterior cortical plate.

Acknowledgements

The author is indebted to Mr. R. Renton, Technical Department, Edinburgh School of Dental Surgery, for assistance with the illustrations, and to Miss M. Robbie for secretarial assistance.

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DISCUSSION

Mr. A. Cockburn, opening the discussion, said that his personal experience of the Begg technique was such that it allowed him, in premolar extraction cases, to accomplish improvements in Class II, division 1 incisor relationships that he previously could not manage to do. He often wondered, however, which technique he would favour if he had an edgewise training.

Was the Begg technique really any less damaging to the supporting tissues in the long run than a well executed edgewise technique with headgear? Begg Stage 2 elastics could be very fierce and oral hygiene in Stage 3 could be a problem. Was its current popularity due to the fact that it demanded less chair-side time, rather than to its being more physiological? It was certainly not much quicker.

The Brandt type of auxiliary for incisor apical movement interested him, it would seem to be easier to bend. He noted that it was not active on the lateral incisors.

Was there any reason for sloping the buccal tubes? Was an oval buccal tube at an angle to the occlusal surface better than a round tube parallel to the occlusal surface?

Using the Begg technique, he would say that one could get into trouble faster and further than with any other technique he had used, so it was definitely not a technique for the enthusiastic amateur. Would Mr. Haynes agree with this viewpoint?

Mr. Haynes, in reply, said he could not really answer Mr. Cockburn on which was the less traumatic, the edgewise or Begg. He thought it was significant that a lot of men who were trained in the edgewise method had switched over to the Begg technique and they claimed that this was because they did not like their patients being subjected to forces which were in the nature of pounds rather than ounces. The elastic force which he used and which he always measured was no more than 2–3 ounces.

In Stage 3, however, the amount of pressure applied to the teeth was debatable. One could not measure the torquing force accurately. He thought that in Stage 3 a lot of experience was required before one could say the right amount of force was being applied. In the first case shown the incisors were excessively torqued, as there was a tendency to apply more force than necessary from the torquing arches. Oral hygiene was certainly something which had to be watched.

The question of the Brandt torquing arch rather than the Begg arch was interesting, but he did not think the Brandt type was simpler to bend. The Begg torquing arch could be constructed in a few minutes, but the Brandt one took four or five times longer. It was interesting that although the Brandt torquing arch did not specifically act on the upper laterals those teeth were obviously torqued at the end of Stage 3. This was something that was not understood. Brandt himself did not understand it. In the same way the correction of the lower incisors in Stage 3 was difficult to explain, as at the beginning they were retroclined whereas at the end they assumed a more normal angulation. The effects of reciprocal anchorage in the final stage of the Begg technique were extremely important.

He did not think it mattered whether the buccal tube on the molar was oval or round so long as it was sufficiently large internally to receive the archwires without any binding whatsoever. The technique had to be a frictionless method, and although the archwires were applied to the brackets by either ligatures or pins, the wire was free to slide and was not braked in any way by either tight ligatures or tight pins, otherwise the whole thing went wrong. The tilting of the buccal tubes on the molar bands was obviously not necessary. People who did not do this put in an anchorage bend which was greater in degree, whereas if the buccal tubes were gently inclined, the anchorage bend need not be so severe. It was more a question of preventing anchorage failure rather than anything else.

Certainly one could get into trouble quickly, and hence the need for all the various attachments at the beginning of treatment. They may never be needed, but they could save one from having to take off a band and put on another attachment if required.

CHANGES IN CROWDING AND SPACING OF THE TEETH WITH AGE

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WHETHER there is crowding or spacing of the teeth in the dental arches will depend on the relationship between the available space in the arches and the size of the teeth. Thus, crowding may be due either to relatively small arches or to relatively large teeth, while spacing may have the reverse explanation (*Fig.* 1). Changes in the space conditions with age may therefore presumably be due to changes in the sum of the mesiodistal tooth widths and/or in the size of the tooth-bearing part of the arch (the arch perimeter). If the shedding period, and hence the major associated changes in tooth width, are left out of account, there will normally be only moderate reductions in tooth width, such as may occur in connexion with abrasion or through proximal caries, unless the tooth width is fully restored by conservative treatment. Any appreciable change in the spacing conditions will therefore be accompanied by an increase or decrease in the lateral or anteroposterior dimensions of the arches.

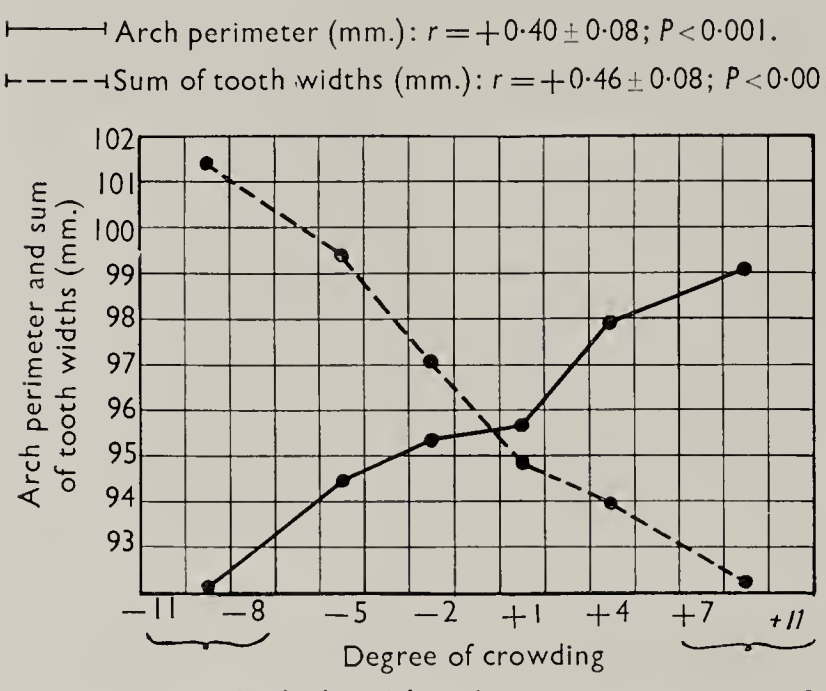

Fig. 1.—Relationship between degree of crowding and spacing, and the mean sum of the mesiodistal tooth widths (M_1–M_1) and the arch perimeter in the same segment. Marked crowding appears primarily in arches with large teeth and short perimeter, while spacing is found chiefly in arches with small teeth and long perimeter. (Reproduced from *Trans. Eur. orthod. Soc.*, 1951, **176**).

In view of the special and complex conditions that prevail during shedding, I shall disregard this period in the present context and in the following survey of the literature I shall refer only to studies concerned with space changes during the deciduous period, and the period after shedding of all the deciduous teeth. The study that will then be presented relates to the latter period.

LITERATURE

The Deciduous Dentition

The studies that are of prime interest in this connexion are the longitudinal ones concerned with the stage when the deciduous dentition is complete to the time when the first molars come into occlusion—that is to say, in general between the ages of 3 and 6 years. So far as the composition of the material is concerned it may be wondered which is best from the odontologic aspects—unselected materials or materials with ' normal occlusion '. The former obviously give more generally valid conclusions, but observations on special groups of cases in such materials may be of interest in particular respects.

Among the studies of the former type may be included the first three listed in *Table I*, which gives means for changes with age during the deciduous period. It is seen that the dental arch increases slightly in width but decreases a little in length. As regards Moorrees's material (1959), it does not meet the requirement of a selection on non-dental grounds, since it is limited to subjects with normal dentitions at 17–19 years.

The changes referred to in *Table I* are, on the whole, confirmed by other articles that report observations on growth during the deciduous period. Such longitudinal observations or studies have been published by Colyer (1920), Friel (1927), Chapman (1935), Baume (1943; 1950 a, b, c, d), Clinch (1951), Barrow and White (1952), and Neumann (1954).

Since the width of the dental arch increases while the length decreases it is conceivable that

Presented at the Jubilee Meeting held on 10 May, 1968.

the degree of spacing or crowding will, on average, remain unchanged. Measurements of such changes were carried out by Moorrees (1959); he reported a slight decrease in spacing between 4 and 6 years, with a total decrease in the maxilla of 1·9 mm. for boys and 0·2 mm. for girls and, in the mandible, of 0·5 and 1·3 mm. respectively. These values are based on 10–17 subjects at 4 years and 17–18 at 6 years; thus most but not all of the subjects had been measured at both these ages.

The Permanent Dentition

Longitudinal studies showing space changes in the young permanent dentition are relatively few. Chapman (1935) gave a good illustration of increasing crowding from about 14 to 18½ years. A group of 40 subjects, 24 of whom had had no orthodontic treatment that might affect the development, were followed by Brown and Daugaard-Jensen (1950–51) from on average about 13 years to a little over 21 years. They displayed a fairly large variation in width changes, there being an increase in some and a decrease in others. The arch perimeter, on the other hand, became shorter in all the maxillae and in all but one of the mandibles (mean in both jaws, 1·6 mm.; range −0·4 to −4·7 mm. for the maxilla and +0·4 to −3·8 mm. for the mandible). A tendency towards greater crowding was recorded for 6 maxillae and 11 mandibles. A reduction in spacing was found in 2 maxillae. The other subjects (16 maxillae and 13 mandibles) showed no changes.

Barrow and White (1952) reported similar results to Brown and Daugaard-Jensen in 51 subjects (same series).

Moorrees (1959) found on average relatively small changes in the arch dimensions between 13 and 17–19 years, but this may be due to the selection of subjects whose dentitions were normal at the end of the study. There was, however, a similar tendency in the mandibles of both sexes, where the available space decreased by 0·7 mm.

Knott (1961) examined 29 children from Iowa with 'good' occlusion, ranging from 'acceptable' to 'excellent'; she measured the width of the dental arch at the second deciduous molars, and length anteroposteriorly from these teeth to the central incisors. All the subjects had been followed from 9 to 15 years, and some from 9 to 16–17 years. After 13 years there were only minor changes in the width of the upper and lower arches (+1·0 and +0·6 mm. for the men and no change for the women). As regards the arch length there was a shortening in both sexes, of −1·4 and −1·4 mm. for the men and −1·4 and −1·0 mm. for the women.

Sillman (1964) performed measurements of the dental arch on a longitudinal series comprising 65 subjects, 40 of whom were followed from birth to 20 years or more up to 25 years. The results are reported as growth diagrams showing

Table I.—Changes in Arch Dimensions with Age in the Complete Deciduous Dentition (mm.)

Study	Material		Arch Width (c–c)		Arch Width (e–e)		Arch Length (e–e to a–a)	
	No. of subjects	Follow-up period	Upper	Lower	Upper	Lower	Upper	Lower
Lewis and Lehman (1929)	170*	3–6½	+0·2	+0·3	+0·7	+0·4		
Goldstein and Stanton (1935)	94–69†	3–6	+1·5	+1·2	+1·4	+0·6	−0·5	−0·7
Cohen (1940)	15F	3½–6½	+1·0	+1·5	+0·9	+0·4		
	13M		+2·0	+1·7	+0·6	+1·2		
Holcomb and Meredith	50F		+0·8	+1·0				
(1956)	50M		+0·6	+0·8				
Meredith and Hopp	40F	4–6			+1·1	+0·7		
(1956)	37M				+0·9	+0·6		
Moorrees (1959)	70–78‡	4–6	+0·2	+0·7	+0·2	0·0	−0·8	−0·3
			+0·4	+0·8	+0·3	+0·7	−0·7	−0·5
Sillman (1964)	65	3–6	+1§	+1	+2	+1	−1	−0·5
			+1	+1	+2	+1	−1	0

*Whole material: at ages 3–6½ years the number varied between 25 and 52 individuals.
†Material of 300 children studied between 1 and 11 years of age.
‡Whole material comprised 184 North-American white children, from whom 78 upper and 70 lower arches were selected as having a full complement of teeth in normal position at the end of the examination (17–19 years). Between ages 4 and 6 years the number varied between 20 and 59 in each age and sex group.
§Approximate figures obtained from growth curves.

the annual changes. Between 14 years and adulthood (21 years) the arch width is largely unaltered (a reduction of about 1 mm. for the women, at the level of the first molars in the maxilla and the canines, in the mandible). The arch length, measured to the central incisors from a line through the contacts between the second premolars and first molars, showed a mean shortening of about 2 mm. in both jaws.

To summarize, in the young permanent dentition the development is characterized by small changes in arch width, while there is some shortening of the dental arches. Individual variations are quite large.

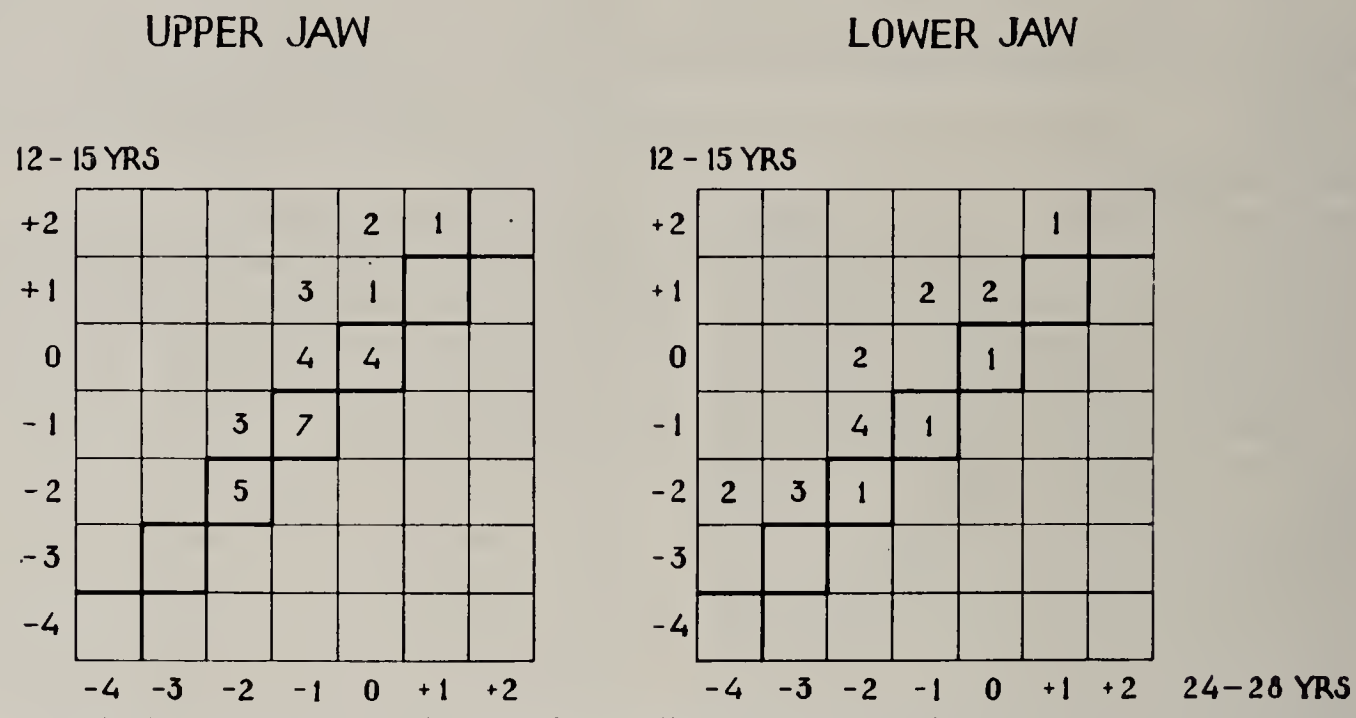

Fig. 2.—Displacements in the degree of crowding and spacing in subjects with ' complete dental arches ', aged about 12–15 years. Upper Jaw: No change, 16; Decrease of space, 14 (moderate, 9; marked, 5). Lower Jaw: No change, 3; Decrease of space, 13 (moderate, 7; marked, 6).

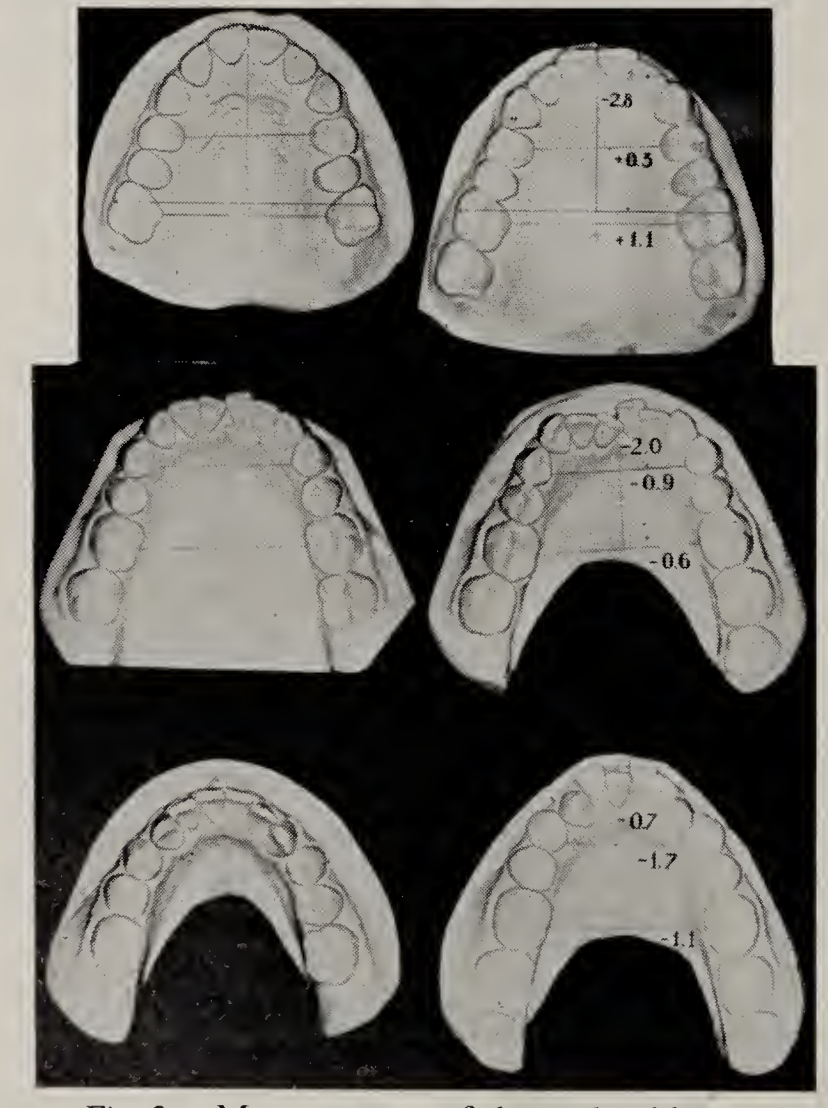

Fig. 3.—Measurement of the arch width at the first premolar and the first molar, and of the arch length, measured as the distance between the line joining the first molars and the incisal edge of the central incisors.

ORIGINAL STUDY

The present study is based on a series of 100 twin pairs examined for the first time in 1952–53 and since reported in a series of articles. At the first examination most of the twins were aged 12–15 years, and the range was 9–19.

Table II.—Age and Sex Distribution

Follow-up Period (years)	Number of Twin Pairs
9–23	2
11–25	2
12–26	10
13–27	9
14–28	5
15–30	7
16–30	1
17–31	1
18–32	3
19–32	1
Total 41 (25M and 16F)	41

Attempts were made to examine these twins again in 1965 and 1966 when they were 26–30 years (range 23–32 years). For various reasons, mainly lack of time and interest in a new examination, and removal of one or both of the twins to an address far from Stockholm, only 41 pairs

were obtained for the new examination. The loss of practically 60 per cent is so large that the representativeness of the material is doubtful. There is, however, no particular reason to suspect the presence of factors of selection of relevance to the study.

The age and sex distributions are shown in *Table II.*

For determination of the changes with age a subjective grading was made of the displacements

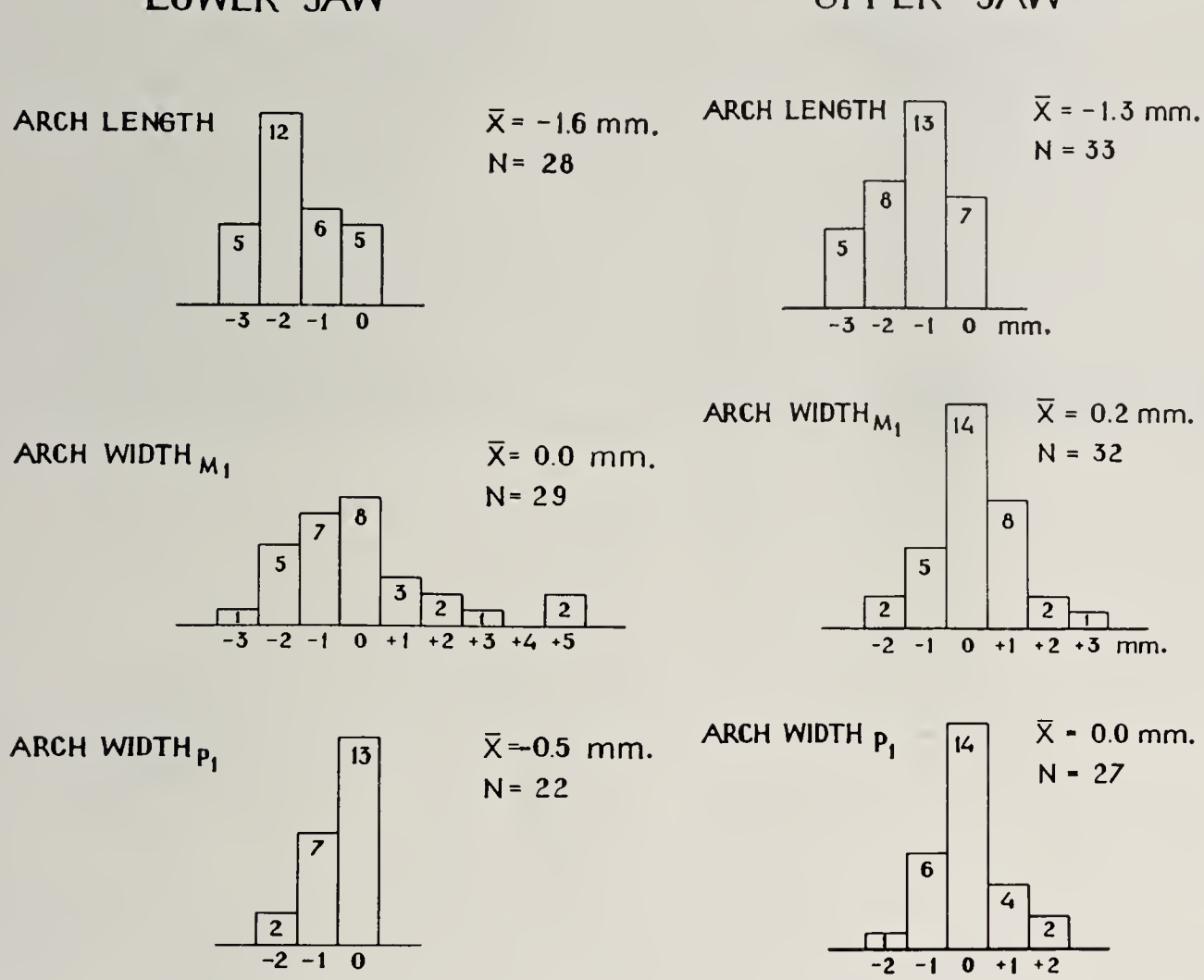

Fig. 4.—Changes in arch width and length between the two examinations.

towards increased crowding or increased spacing of the twins that were 12–15 years old at the beginning of the study (one twin from each pair). In addition to the perfectly even arches the scale includes four classes for crowding and a like number for spacing (only two of the latter were represented in the material, however). The spacing was denoted as positive (+1 or +2), even arches as 0, and crowding as negative (−1, −2, −3, or −4). The registration of the displacement towards increased crowding or spacing in the individual subjects may be considered to be fairly reliable. The grading of the various subjects according to class is probably less reliable; for instance the same degree of crowding in two subjects may have been assigned to different classes, but the error will most probably not have been greater than one class. The results of the registrations are shown in the diagram in *Fig.* 2. For the maxillae the number of subjects displaying no change in spacing (16 subjects) was approximately the same as the number showing a reduction in spacing or an increase in crowding (14 subjects). For the mandibles most of the subjects show loss of space (16 subjects), and only a few (3 subjects) no change.

The observed changes imply reductions in either the transverse or anteroposterior dimensions of the arch. To examine this, the arch width and length were measured in the manner shown in *Fig.* 3. Care was taken to obtain reference points that could be clearly identified on the casts of the individual subject at the two examinations.

As *Fig.* 4 shows, it was mainly the length of the arch that was reduced, by a mean of 1–2 mm. The arch width at the first premolars and first molars sometimes showed an increase and sometimes a reduction, the means not differing greatly from zero, with the possible exception of the lower arch at the first premolar, where a reduction was measured in 9 out of 22 subjects, and no change in the other 13.

As regards the reasons for the shortening of the arches there are a number of factors that may be responsible. An attempt was made to analyse the relative importance of 5 such factors in subjects with a fairly large decrease (at least 2 mm.); the results are given in *Table III.*

In *Table III* primary and secondary factors are distinguished, the former constituting important, and the latter contributory, causes. It is evident

that some importance attaches to local factors, that is, replacement of the second deciduous molars by the narrower permanent premolars, and a reduction in the tooth width of the permanent teeth through caries or proximal abrasion, but it is also evident that in several subjects there was a reduction in the perimeter of the arch that was not due to such factors. Here there was a more or less obvious decrease in spacing or increase in crowding (*Fig.* 3). In one subject the shortening of the arch was accompanied by an increase in the transverse dimension with the result that the degree of crowding remained unchanged (*Fig.* 5).

The measurements indicate a large variation in the tendency towards a reduction in spacing.

Fig. 5.—Subjects with a fairly large increase in arch width and a shortening of the arch, the space conditions thus remaining unchanged. Due to a large increase of the lower arch width this case developed into a buccal occlusion of lower to upper molars on the left side.

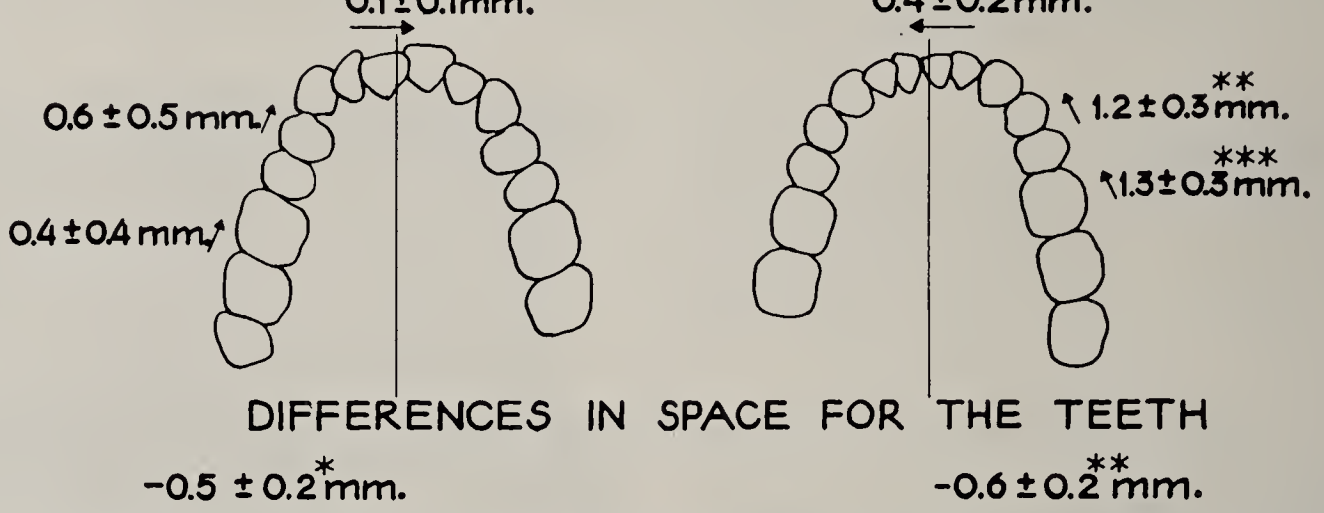

Fig. 6.—Differences in the mesiodistal direction between the two sides of the arches in subjects with unilateral congenital absence of the third molars (Bergström and Jensen, 1961).

Table III.—Evaluation of Factors Contributing to the Reduction in Arch Length

Factors	Decrease in Arch Length			
	Upper (10 Subjects)		Lower (10 Subjects)	
	Primary factor	Secondary factor	Primary factor	Secondary factor
Mesial migration $\frac{6\|6}{6\|6}$ after shedding of $\frac{E\|E}{E\|E}$	3	5	4	3
Reduction of tooth diameters:				
a. Due to caries	1	3	–	3
b. Due to attrition	–	1	–	1
Reduction of arch perimeter, with loss of available space	5	4	5	2
Change to broader and shorter dental arch	1		1	

What is the explanation of this variation? One possible factor is the presence of the third molars. It was found by Selmer-Olsen (1937) and Bergström and Jensen (1961) that a unilateral absence of the third molars results in difference between the left and right sides as regards the anteroposterior location of the lateral teeth (*Fig.* 6). Vego (1962) reported corresponding findings in comparing space-loss between 13 and 18 years for mandibles with (40 subjects) and without (25 subjects) third molars. On an average he found space-loss of 2·5 and 1·7 mm. respectively with ranges of 0·3–7·6 mm. and 0·2–4·0 mm. The present series, however, shows no evidence of such aplasia that might account for the differences between the subjects.

Biologically, the observed tendency might be conceived as Nature's way of maintaining contact between the teeth despite marked abrasion; but nowadays abrasion is only slight. The differences are more likely to be due to the position of the teeth in the arches. The mechanism for migration may possibly be found in a contractile tendency of the interdental ligament system. From the aspect of clinical orthodontics, the observed trend towards the secondary occurrence of crowding is obviously of great interest. It might be wondered whether the extraction and appliance therapy to relieve crowding should be directed so as to achieve complete closure of extraction spaces, as such treatment may result in relapse of crowding in the anterior segment, particularly in the mandible. Also, the development of crowding in the lower arch following orthodontic treatment for postnormal occlusion need not be ascribed to the treatment, whereby the lateral teeth are forced forwards. Rather, it is due, at least in some cases, to a developmental trend.

SUMMARY

The present results, in common with those obtained in earlier studies, indicate that a reduction of spacing of the teeth with age and an increase in crowding are a fairly common development in both the deciduous dentition and in the young permanent dentition. Measurements on arches have shown that the trend is due more to a reduction in the anteroposterior than in the transverse dimensions (*Fig.* 4). The recorded shortening of the arch perimeter may be ascribed in some measure, but not entirely, to certain local factors. A reduction in the arch perimeter is thus not infrequently due to a mesial migration of the lateral teeth or, possibly, to the anteriors being forced backwards.

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DISCUSSION

Mr. E. K. Breakspear said that he was interested in the comparison between the two sides, one of which had the third molar missing. He asked Professor Lundström what was the base line from which he measured the mesial migration which he had mentioned.

Professor Lundström replied that, in the upper arch, this was not so difficult. He simply used the median line and had a cross line at right-angles, one side being compared with the other. In the lower dental arch, there was no such midline. Instead, a line was drawn connecting the second molar cusp to the canine cusp. The dental arch was projected on paper first, with special R. Schwartz apparatus. The same line was taken on the other side and where these two lines met, the angie had been bisected, and a line taken at right-angles so that a comparison of what had happened could be made. This implied that the arch was more or less symmetrical and that the mesial migration on one side was going more or less in a mesiodistal direc-

tion in relation to the dental arch as a whole. Whether it was strictly reliable, he did not know; that was the way he had tried to do it.

Mr. A. J. Walpole Day said that one feature of all Professor Lundström's cases was the reduction of the incisal segment in the upper and lower arches. Was this consistent with an increased activity of the lips?

Professor Lundström said that the reduction in arch length might be dependent on the lip musculature pressing the front teeth backwards.

If one was looking at skulls especially, it had been shown that the reduction in arch length would be accompanied by some inward tilting of the upper incisors, although he himself believed more in the mesial migration of the lateral teeth than in the change in the front, but he did not really know.

Dr. G. B. Hopkin said that he had two questions. Regarding the mesial migration, one could understand this taking place in the more primitive dentitions where proximal attrition made space for the teeth to migrate. He asked if Professor Lundström had any idea why they should continue to do so in modern dentitions where there was not the same degree of proximal attrition. Had Professor Lundström any advice to give as to how the awkward crowding of the lower arch could be dealt with?

Professor Lundström said that the first question was related to what happened in growth. In growth, there was increased height of the face and the teeth were growing upwards more, but there seemed to be, in this growth process, also a mesial tendency. At least, he believed that. That was the reason, he thought, for this happening. Also, in these cases, in spite of the fact that they might have good contact relations in the beginning, this did develop into crowding later, which was very discouraging. On the other hand, it was good to know about this in clinical work, because many people blamed themselves for this later crowding showing in the lower arch as being a kind of relapse, especially after having treated post-normal cases where, one way or the other, there has been certain pressure on the lower arch forwards. He thought everyone had been afraid that, in doing that, they had moved the lateral teeth anteriorly more than they should and, because of that, this later crowding came along in the front, but it seemed that nature was causing this, irrespective of what they did. They must not blame themselves all the time for this happening.

Dr. J. R. E. Mills said that, arising out of Mr. Walpole Day's question, he thought he was quoting Professor Björk correctly in his investigations using metal implants in the mandible. Professor Björk had illustrated this with a comparatively small number of cases in which he appeared to show that as the anterior alveolus grew upwards, it did not grow straight upwards. In some patients, it grew upwards and backwards; in others, upwards and forwards. Where the alveolus grew upwards and backwards, it was associated with crowding. Where it grew upwards and forwards, the crowding was less. It was a matter of the whole tooth bodily going further back.

He asked Professor Lundström to confirm whether he was right about this, both in his quotation and observations.

Professor Lundström said that Dr. Mills was right in the quotation, and that might be part of the answer. Growth in height was obviously combined with other movements of the teeth and cases differed quite a lot.

REPORTS OF MEETINGS

ORDINARY MEETING, 9 October

AN ORDINARY MEETING of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 9 October, 1967, at 6.30 p.m., with Mr. J. S. Beresford, President, in the Chair.

The PRESIDENT said that it was with sadness he had to announce the deaths, since the last meeting, of Mr. Govans, a Member, Miss Josephine Bradley, a Life Member, and Dr. J. H. Sillman, a Corresponding Member.

Apologies for Absence

Apologies for absence were received from Dr. W. Grossman, Dr. W. Russell Logan, Mr. J. H. Gardiner, and Professor C. F. Ballard.

Minutes

The SECRETARY read the Minutes of the Country Meeting held in Bristol in April, 1967. These were confirmed and signed as a correct record.

Introduction of Members

The following members, whose elections had been confirmed at a previous meeting, were introduced to the PRESIDENT: Mr. P. C. S. Campion, Mr. B. Scheer, and Mr. D. B. Lawton.

Candidates for Election

Life Membership

The PRESIDENT proposed the election to Life Membership of:—

Mr. C. L. Endicott, F.D.S., D.Orth. R.C.S., 22 Harcourt House, 19 Cavendish Square, London, W.1.

Mr. J. H. Hovell, T.D., F.D.S., M.R.C.S.(Eng.) L.R.C.P.(Lond.), D.Orth. R.C.S.(Eng.), 92 Harley Street, London, W.1.

Mr. A. G. Taylor, L.D.S. R.C.S.(Eng.), 51 North End House, Fitzjames Avenue, W.1.

Following their election by acclamation, the PRESIDENT congratulated the new Life Members.

Ordinary Membership

The following were elected:—

Mr. B. Birkinhead, B.D.S.(U. L'pool), 84 Rodney Street, Liverpool.

Mr. D. Foxton, B.D.S.(Lond.), L.D.S. R.C.S. (Eng.), 31 Brookside, Hereford.

Mr. A. B. Hewitt, B.D.S.(Lond.), F.D.S., D.Orth. R.C.S.(Eng.), 5 Priors Road, Hemingford Grey, Hunts.

Mr. F. W. Hunter, L.D.S.(Durham), D.Orth. R.C.S.(Eng.), 4 Cavan Road, Redbourne, Herts.

Mr. A. A. Rhodes, L.D.S.(U. Manc.), 307 Wilmslow Road, Manchester 14.

The PRESIDENT welcomed visitors and introduced Mr. A. M. Cookson, presently at the Royal Dental Hospital, and Dr. Hall of the Christchurch Hospital, Hampshire, and invited Mr. Cookson to read his Short Communication: '*Use of Obturators in the Early Management of a Case of Pierre Robin Syndrome (Pielou's Method)*'.

The PRESIDENT (Mr. J. S. Beresford) then read his Presidental Address. Following the discussion on the Address, a vote of thanks was proposed to the President by Mr. G. G. T. Fletcher.

EXTRA MEETING, 27 October

AN EXTRA MEETING of the Society was held at the Royal College of Physicians and Surgeons of Glasgow, on Friday, 27 October, 1967, at 2 p.m. with the PRESIDENT, Mr. J. S. Beresford, in the Chair.

Apologies for Absence

Apologies for absence were received from Miss D. R. Ridley and Messrs. H. A. Anderson, A. C. Campbell and C. P. Adams.

The PRESIDENT welcomed any visitors who might be present, and then delivered a shortened version of his Presidential Address, which had been read at the previous meeting in London.

The discussion was opened by Professor T. C. White. Following the discussion, papers were read by Mr. J. D. McEwen and Professor W. D. McHugh on '*An Assessment of the Need for Orthodontic Treatment*', and by Mr. S. Haynes on '*Treatment by the Begg Technique in three Different Types of Malocclusion*'.

The discussions were opened by Mr. W. Stevenson and Mr. A. Cockburn respectively, and a number of members took part.

A vote of thanks to the speakers, and to Professor White and Mr. Cockburn who had organized the meeting, was proposed by the President, and carried with acclamation.

A vote of thanks to the President was carried, on the proposal of Dr. W. Russell Logan, after which the meeting terminated.

ORDINARY MEETING, 13 November

AN ORDINARY MEETING of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 13 November, 1967, with Mr. J. S. Beresford, President, in the Chair.

The PRESIDENT announced the death, since the last meeting, of Mr. D. Spirran Jones.

Minutes

The HON. SECRETARY (Mr. Alan C. Campbell) read the Minutes of the meeting held on 9 October, 1967, which were confirmed and signed as a correct record.

The Minutes of the meeting in Glasgow were taken as read.

Apologies for Absence

Apologies for absence were received from Dr. Russell Logan and Mr. G. K. Crofts.

Candidates for Election

The following candidates for election to ordinary membership were elected by show of hands:—

Mr. T. J. Miall, B.D.S.(U. Brist.), L.D.S., R.C.S.(Eng.), 5 Braidwood Terrace, North Hill, Plymouth, Devon.

Mr. D. O. Mole, B.D.S., L.D.S.(U. Birm.), L.D.S. R.C.S.(Eng.), 'The Gables', 9 St. James's Road, Dudley, Worcs.

The PRESIDENT welcomed visitors and invited Mr. W. Frankland to read his short communication: '*Comparison of the Occlusion in a Pair of Twins*'.

Following Mr. Frankland's communication, the PRESIDENT introduced Dr. J. R. E. Mills and invited him to read his paper: '*The Stability of the Lower Labial Segment*'.

ORDINARY MEETING, 11 December

AN ORDINARY MEETING of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 11 December, 1967, at 6.30 p.m. with Mr. J. S. Beresford, President, in the Chair.

Minutes

The Minutes of the Ordinary Meeting held on 13 November, 1967, were read by the SECRETARY and confirmed and signed as a correct record.

Apologies for Absence

Apologies for absence were received from Mr. C. P. Adams, Mr. G. H. Roberts and Mr. J. H. Hovell.

Candidates for Election

The PRESIDENT then proposed the election of Professor R. Selmer-Olsen for Honorary Membership of the Society. This was carried with acclamation.

The PRESIDENT then welcomed visitors and introduced Mr. T. Cradock Henry and Mr. G. Wreakes and invited them to address the Society and to show their two films on '*The Surgical Repositioning of Labial Segments in the Treatment of Malocclusion*'.

ORDINARY MEETING, 8 January

AN ORDINARY MEETING of the Society was held at Manson House, 26 Portland Place, London, W.1., on Monday, 8 January, 1968, at 6.30 p.m., with Mr. J. S. Beresford, President, in the Chair.

Minutes

The HON. SECRETARY (Mr. A. C. Campbell) read the Minutes of the Ordinary Meeting held on 11 December, 1967, and these were confirmed and signed as a correct record.

Apologies for Absence

Apologies for absence were received from Mr. C. P. Briggs, Mr. F. J. Downing, Mr. T. D. Foster, Mr. D. S. Hayton-Williams, Mr. R. E. Rix, and Mr. T. Jason Wood.

Candidates for Election

Life Membership

The PRESIDENT then proposed that the following Members be elected to Life Membership:—

Mr. F. J. Downing, L.D.S., D.Orth. R.C.S. (Eng.), 'Carisbrooke', 238 London Road, Leicester.

Mr. D. S. Hayton-Williams, F.D.S., M.R.C.S. (Eng.), L.R.C.P.(Lond.), 3 Blaydon Close, Oxford.

Miss E. M. Still, L.D.S., D.Orth. R.C.S.(Eng.), 16 Castle Hill, Maidenhead, Berks.

Ordinary Membership

The following candidates were elected to Membership:—

Mr. L. A. Buckley, B.D.S.(N.U.I.), F.D.S. R.C.S.(Edin.), 210 New Road, Chelmsford, Essex.

Mr. I. P. D. Carpenter, B.D.S.(Lond.), L.D.S., D.Orth. R.C.S.(Eng.), D.D.O. R.F.P.S. (Glas.), 'Tangle Trees', Pine Grove, Chichester, Sussex.

Mr. R. J. H. Corfe, L.D.S. R.C.S.(Eng.), 'Combe Hill House', Whiston, Northants.

Mr. P. S. Ellisdon, B.D.S.(Lond.), F.D.S., D.Orth. R.C.S.(Eng.), 27 Osgood Avenue, Orpington, Kent.

Mr. P. D. Jepson, L.D.S, D.Orth. R.C.S. (Eng.), 'Headingley', Dickinson Avenue, Croxley Green, Herts.

Mr. E. E. Lewis, L.D.S.(U. Manc.), ' Blandy House ', Hart Street, Henley-on-Thames, Oxon.

Mr. M. D. Martin, B.Dent.Sc.(U. Dubl.), ' Buckingham House ', Graham Road, Malvern, Worcs.

Mrs. E. M. B. Mason, L.D.S.(U. St. And.), ' Rhu-Na-Dee ', Cults, Aberdeen, AB1 9NA.

Mr. J. Page, B.D.S.(Lond.), L.D.S. R.C.S. (Eng.), 65 Mount Ephraim, Tunbridge Wells, Kent.

Mr. R. J. Rose, B.D.S.(Lond.), L.D.S. R.C.S.(Eng.), 22 Grenville Gardens, Birchington, Kent.

Corresponding Members

Mr. P. J. Rogers, B.D.S.(U. Birm.), D.Orth. R.C.S.(Eng.), 3rd Floor, Macquarie House, 173 Macquarie Street, Hobart, Tasmania.

Mr. M. F. Tam, B.D.Sc.(U. Queensland), D.D.O. R.C.P.S.(Glasg.), D.Orth. R.C.S.(Eng.), c/o Kwong Hup Cheong, 31 Hugh Low Street, Ipoh, Malaya.

The PRESIDENT said that both the speakers were well known and it gave him great pleasure to welcome to the lectern Mr. J. Nicolls to read his paper on ' *Frictional Forces in Fixed Orthodontic Appliances* '.

Following the discussion of Mr. Nicolls' paper, the PRESIDENT invited Mr. D. A. Dixon to address the Society on ' *The Potentialities of the Universal Bracket* '.

ORDINARY MEETING 12 February

AN ORDINARY MEETING of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 12 February, 1968, at 6.30 p.m., with Mr. J. S. Beresford, President, in the chair.

The PRESIDENT reported the death of Mr. Barrington Ely, and the meeting stood in silence.

The minutes of the previous meeting were confirmed and signed as a correct record.

The SECRETARY reported apologies for absence from Messrs. E. K. Breakspear, W. Frankland, D. H. Oliver, and C. D. Parker.

Introduction of Members

The following members whose election had been confirmed at a previous meeting were introduced: Mr. J. Page, Mr. R. J. H. Corfe, Mr. I. P. D. Carpenter, and Mr. R. J. Rose.

Candidates for Election

The following candidates were elected to Ordinary Membership:—

Mr. P. S. Robson, B.D.S.(Dunelm), F.D.S., D.Orth. R.C.S.(Eng.) 11 Yeomans Avenue, Harpenden, Herts.

Mr. D. W. Williams, B.D.S.(Lond.), L.D.S., D.Orth. R.C.S.(Eng.), Flat 4, 40 Yonge Park, London, N.4.

The PRESIDENT welcomed any visitors and called upon Mr. A. B. Hewitt to present a short communication: ' *A Study of a Pair of Twins treated with Intermaxillary Traction.* '

The PRESIDENT thanked Mr. Hewitt, and called upon Mr. Ardouin to present the Chapman Prize Essay, 1967, entitled ' *Investigations into Changes in some Mandibular Arches in the Postdeciduous Dentition* ', by Mr. D. G. F. Ardouin and Mr. M. L. Brenchley.

Following discussion of the Prize Essay, the PRESIDENT presented the Chapman Prize to Messrs. Ardouin and Brenchley.

ORDINARY MEETING, 11 March

AN ORDINARY MEETING of the Society was held at Manson House, 26 Portland Place, London, W.1, on Monday, 11 March, 1968, with Mr. J. S. Beresford, President, in the Chair.

Minutes

The Minutes of the Ordinary Meeting held on Monday, 12 February, 1968, were read by the SECRETARY and signed as a correct record.

Apologies for Absence

Apologies for absence were received from Mr. J. F. Pilbeam and Mr. D. Munns.

Introduction of Members

The following members were introduced to the President and signed the Obligation Book: Mr. P. S. Robson, Mr. D. W. Williams.

Candidates for Election

The following candidates were elected by show of hands:—

Ordinary Membership

Mrs. J. K. Combes, B.D.S.(Lond.), D.Orth. R.C.S.(Eng.), 13 New Close, Knebworth, Herts.

Mr. T. J. Combes, B.D.S.(Lond.), D.Orth. R.C.S.(Eng.), 13 New Close, Knebworth, Herts.

Mr. M. J. Downing, L.D.S. R.C.S.(Eng.), 238 London Road, Leicester.

Mr. R. B. Erskine, B.D.S.(U. St. And.), School of Dental Surgery 31 Chambers Street, Edinburgh.

Mr. J. D. Muir, B.D.S.(U. Birm.), F.D.S., D. Orth. R.C.S.(Eng.), 6 Rokeby House, Lamb's Conduit Street, London, W.C.1.

Miss D. A. Paton, B.D.S.(U. Edin.), D.D.O. R.C.P.S.(Glas.), 53 Pirniefield Place, Edinburgh 6.

Mr. A. J. Rodesano, B.D.S.(Lond.), L.D.S., D.Orth. R.C.S.(Eng.), ' Macavity ', Sheephouse Road, Maidenhead, Berks.

Mr. W. G. Webb, B.D.S.(Lond.), F.D.S., D.Orth. R.C.S.(Eng.), 3 Eynsford Rise, Eynsford, Dartford, Kent.

Corresponding Membership

Mr. J. J. G. G. de Muelenaere, B.Ch.D. (U. Pretoria), 985 Church Street, Arcadia, Pretoria, South Africa.

Mr. R. M. McAnuff, L.D.S., B.D.S., B.Sc. (Q.U. Belfast), c/o Medical and Health Department, Hamilton, Bermuda.

Mr. Y. S. Tsang, B.D.S.(U. Singapore), D.Orth. R.C.S.(Eng.), 63 Robinson Rd., 3rd Floor, Hong Kong.

The PRESIDENT welcomed guests and introduced Mr. D. J. Timms who addressed the Society on '*An Occlusal Analysis of Lateral Maxillary Expansion with Midpalatal Suture Opening*'.

Following Mr. Timms' paper, Mr. D. T. Bennett read a paper entitled '*Reinforced Occipitomental Traction and its Effect on the Incisor Teeth in Class III Malocclusions*'.

RESEARCH MEETING, 9 May

THE RESEARCH MEETING of the Society was held at the London Hospital Medical College at 2.0 p.m. on Thursday, 9 May, 1968. The PRESIDENT, Mr. J. S. Beresford, occupied the Chair, and papers and research reports were presented as follows:—

2.00 p.m. Research Report Session:—

Mr. A. G. Huddart: '*Studies in the Form and Dimension of the Pre-deciduous Maxillary Arch in Unilateral Cleft Lip and Palate Cases*'.

Mr. D. G. Huggins and Mr. B. B. J. Lovius: '*Vital Transplantation of Teeth*'.

Dr. J. K. Luffingham: '*Pressure exerted on Teeth by the Lips and Cheeks*'.

Mr. J. P. Moss and Dr. D. C. A. Picton: '*The Problems of Dental Development among Children on a Greek Island*'.

Mr. N. R. E. Robertson: '*A Method of Demonstrating Changes produced by Presurgical Oral Orthopaedics*'.

ANNUAL GENERAL MEETING, 10 May

THE ANNUAL GENERAL MEETING of the Society was held at London Hospital Medical College, London, E.1., on Friday, 10 May, 1968, at 9 a.m., with the President, Mr. J. S. Beresford, in the Chair.

Apologies for Absence

It was agreed to take the apologies for absence as read.

Minutes

The Minutes of the last Annual General Meeting were read by the SECRETARY, confirmed and signed as a correct record.

Election of Officers and Councillors

The PRESIDENT said that nominations for Council office were set out on the Agenda. Five Councillors were required in addition to the other Officers. There were four nominations from the Council and Mr. J. D. Atherton had been properly nominated. There being no other nominations he declared the following elected:—

President:	Mr. T. Jason Wood
Immediate Past President:	Mr. J. S. Beresford
President Elect:	Mr. J. H. Gardiner
Senior Vice-President:	Mr. J. F. Pilbeam
Vice-President:	Professor B. C. Leighton
Councillors:	Mr. C. P. Adams
	Mr. J. D. Atherton
	Mr. T. D. Foster
	Mr. W. Frankland
	Mr. R. W. Willcocks
Treasurer:	Mr. J. S. Rose
Secretary:	Mr. M. S. E. Gould
Assistant Secretary:	Miss J. G. Ritchie
Editor:	Dr. J. R. E. Mills
Curator:	Mr. R. D. Howard
Librarian:	Mr. A. C. Campbell.

Election of two Auditors

A motion that Mr. Burke and Mr. Walpole Day be elected auditors was proposed, seconded and carried.

Hon. Treasurer's Report

Mr. J. S. ROSE said that the accounts for 1967 showed a more cheerful picture than the previous two years. However, they were not strictly comparable because the accounts for 1966 represented fifteen months of the Society's affairs whereas those now before the meeting covered a twelve month period.

This year an excess of income of £405 had been shown, but £246 of this amount came from an over-reserve for the costs of printing the TRANSACTIONS for 1966. In effect, this meant that the Society had made a profit of £94 in 1966 instead of a loss of £152, but the 1967 excess income was only £160 in real terms. Part of this amount was made up by the increase in the sale of the TRANSACTIONS which were now charged at a higher figure than previously. Once more he wished to express his appreciation to the Honorary Librarian for her continually successful results in the sale of the TRANSACTIONS. In fact, therefore, the budget barely balanced.

There had been no changes in the Society's investments during 1967, but the 1200 National Savings Certificates had matured and earlier in the year were cashed and re-invested in Liverpool Corporation Stock. Members would have noted that the market value of the portfolio had increased by £1300 during the past year.

Next year would see the first results following the raising of the subscription for membership of the Society, and he anticipated that there would be a healthy surplus of income.

This year, Mr. Pilbeam had been nominated as the Senior Vice-President and was therefore retiring from being an Honorary Auditor. He wished to take the opportunity of expressing his

thanks to Mr. Pilbeam for all the careful work that he had done and for the helpful suggestions that he and his co-auditor, Mr. Burke, had made. He was glad that Mr. Burke had agreed to stand again and was grateful for his continuing efforts on the Society's behalf.

The Treasurer moved the reception of the report and Dr. J. R. E. Mills seconded.

There being no discussion, the PRESIDENT moved the adoption of the report, which was carried.

Hon. Secretary's Report

Mr. A. C. CAMPBELL said that at the seven meetings held since his last report in April, 1967, there had been an average attendance of 107 members and visitors, which was an increase over the year before. In addition, there had been an extra meeting in Glasgow in October, 1967, attended by 41 members and visitors, including almost all the B.S.S.O. members in Scotland. It was hoped that further one-day additional meetings held away from London would be received equally well. He expressed sincere thanks to those members in Scotland who had done so much of the secretarial and organisational work required.

The Society had continued to grow, in spite of the need to increase the annual subscription. Thirty-seven members had been lost through death and resignation during the year, but one of last year's resignations had been cancelled. The Society had been joined by 33 new Ordinary Members and six new Corresponding Members, a net increase over the year of 3, giving a total of 599. It was a healthy sign that the Society continued to grow with such vigour, having increased by something over 200 in the past 14 years—that was the period covered by the last three Secretaries—and at a net rate in excess of 14 new members per annum during the last five sessions and actually, 161 new members during that time.

In his last report as Secretary, his predecessor, Professor Leighton, noted that some reinforcement of the secretariat would be needed in due course, and this had been implemented by the election of Mr. C. P. Briggs to a new office in the Council as Assistant Secretary. He and the Society were greatly indebted to him for the work he had done.

Further changes during his five-session term of office had been a change in the Society's year, making this the third Annual General Meeting in May, the earlier time of meetings, and more superficially, a change in the format of the Society's stationery.

He wished to thank all those who had simplified his task, and in particular, Professor Leighton, Mr. Rose, Dr. Mills, and succeeding Presidents. He knew that the office was passing into most capable hands and only hoped that he could turn things over to Mr. Gould in as good order as he had received them from Professor Leighton.

He moved the reception of the report. Miss J. Ritchie seconded.

The PRESIDENT moved the adoption of the report, which was carried.

Hon. Editor's Report

Dr. J. R. E. MILLS said that the year had been a comparatively uneventful one. The Society's TRANSACTIONS had continued to be published in the *Dental Practitioner* and volumes of the TRANSACTIONS for 1966/67 were now with the binders. They should be delivered to Members during the summer.

The Editorial Committee had continued to plan the scientific programme and would shortly be considering this for the coming winter. He and the Secretary would be pleased to receive offers of papers for consideration. They particularly required short papers of a practical or technical nature. He moved the reception of the report, which was seconded by Mr. T. D. Foster.

On a motion of the President, the report was adopted.

Hon. Curator's Report

Professor B. C. LEIGHTON said that he was very glad to report two donations to the Museum. Mr. M. A. Kettle had presented a collection of study models depicting cases of cleft palate and their treatment. Mr. C. H. Mielewski had given a pair of models with his own modification of the mouth shield, and another showing a supplemental lower incisor.

It was thought a few months ago that it might be possible to obtain sole possession of a small room in the Institute of Public Health and Hygiene for the Museum and Library. Unfortunately, the Institute decided that they needed the room after all and it was, therefore, not available. As the present accommodation was still unsatisfactory, efforts were being made to seek accommodation outside the centre of London. Until this was found, the Museum would continue to be housed at No. 28 Portland Place, where it might be visited between 10 a.m. and 5 p.m. It would be wise to warn the Curator of the visit beforehand, so that access to the cabinet drawers might be provided.

The custom of bringing some portion of the Museum before the members at the Country Meeting had been maintained this year. It seemed appropriate in this Jubilee year to take orthodontics in the year 1908 as the theme of this demonstration.

Finally, he had to hand the keys of the Museum to Mr. Howard, in whose care he knew they would be safe. He proposed the reception of the report.

The motion was seconded by Dr. J. R. E. Mills.

On the motion of the President, the report was adopted.

Hon. Librarian's Report

Miss J. G. RITCHIE thanked Mr. Stuart Smith and Mr. R. A. Campbell for their most generous donations of past TRANSACTIONS to the Society. These gifts had enabled the Society to supply past TRANSACTIONS for which there was an increasing demand, from overseas in particular. The sale of TRANSACTIONS to non-members continued at the previous level.

Because of the acute shortage of accommodation for the Library and Museum, the Council had carefully considered alternatives. The British Dental Association had agreed to house the Library of the Society. Before transferring this, the rare books—those printed before 1900—had been moved to the Museum, together with one complete set of the Society's TRANSACTIONS.

The remaining books, 57 in number, together with two complete sets of TRANSACTIONS had been transferred to the Library of the British Dental Association in Wimpole Street, where they were housed on shelves which were clearly designated as belonging to the B.S.S.O. All orthodontic journals were being bound before transfer. She drew the attention of Members to the notice regarding missing journals which was printed with the notice of the Meeting. It would be a most welcome and valuable donation to the Society if all volumes could be complete.

She was handing over her duties as Librarian. The affairs of the Library would now be in the extremely capable hands of the retiring Secretary, Mr. A. C. Campbell.

Miss Ritchie moved the reception of the report. The motion was seconded by Professor B. C. Leighton.

On the motion of the President, the report was adopted.

Any Other Business

Mr. F. Allan complained about the presentation to the Society of papers which contained statistics, graphs, and abbreviations used in cephalometrics, and in particular complained that he had been unable to understand the paper '*The Stability of the Lower Labial Segment*' by Dr. Mills. He suggested that synopses of papers should be circulated to members with the notice of the appropriate meeting.

He also complained that his contributions to the discussion of papers were censored by the Editor, and all the relevant bits cut out.

The PRESIDENT thanked Mr. Allan. He had had no difficulty in understanding Dr. Mills' paper. The Council had considered the idea of circulating synopses of papers, and would doubtless consider it again, but it was expensive, and there was doubt whether the expense was justified.

The HON. EDITOR (Dr. J. R. E. Mills) resented the suggestion that he censored the discussion of papers. It was necessary to condense the discussion, and in addition he eliminated remarks which were superfluous, irrelevant, or unintelligible, and also those which might be legally actionable. He felt that Mr. Allan had had a very fair share of the available space in the TRANSACTIONS.

The PRESIDENT thanked members for their attendance and the meeting terminated.

DIAMOND JUBILEE MEETING, 10 and 11 May

THE DIAMOND JUBILEE MEETING of the Society opened at the London Hospital Medical College, London, E.1, at 9.30 a.m. on Friday, 10 May, with the President, Mr. J. S. Beresford, in the Chair.

Minutes

The SECRETARY read the minutes of the previous Ordinary Meeting, which were confirmed and signed as a correct record.

The PRESIDENT announced that the Society had received many telegrams of congratulations on the occasion of its jubilee, notably from the American Association of Orthodontists and the Orthodontic Societies of France, Holland, and Norway.

Candidates for Election

Life Membership

The PRESIDENT presented to the Society for election to Life Membership, the name of Mr. J. W. Mayer. The motion was carried by acclamation.

Ordinary Membership

The following candidates were elected to Ordinary Membership *en bloc* by show of hands:—

Mr. P. G. Arnold, L.D.S. R.C.S.(Eng.), 18 Angus Close, Upper Willingdon, Eastbourne, Sussex.

Mr. R. J. M. Cobb, B.Ch.D., L.D.S.(U. Leeds), 31 Park Square, Leeds 1.

Mr. M. J. Murgatroyd, B.D.S.(U. Manc.), 'Fern Lea', Church Road, Mellor, Nr. Stockport, Cheshire.

Mr. R. T. Reed, B.D.S. (U. Glasg.), D.Orth. R.C.S.(Eng.)., 73 Grantchester Meadows, Cambridge.

Mr. B. C. Rich, B.D.S.(Lond.), L.D.S. R.C.S.(Eng.), 'Longdene Lodge', Haslemere, Surrey.

Mr. D. A. H. Roberts, B.D.S.(Lond.), Joyce Green Hospital, Dartford, Kent.

Corresponding Membership

The following candidate was elected to Corresponding Membership:—

Mr. S. B. Choo, B.D.S.(U. Adelaide), D.D.O. R.C.P.S.(Glasg.), D.Orth. R.C.S.(Eng.), 44 Caunter Crescent, Penang, Malaysia.

The Programme of the Meeting was then presented, as follows:—

Friday, 10 May

9.45 a.m. 22nd Northcroft Memorial Lecture: Professor M. L. Moss: '*The Primacy of Functional Matrices in Orofacial Growth*'.

11.00 a.m. Coffee.

11.30 a.m. Chairman: Professor W. J. Tulley. Paper: Miss D. R. Ridley: '*Class III Occlusions in Patients with Cleft Lip and Palate*'.

12.15 p.m. Case Report: Mr. M. L. Brenchley: '*A Speech Problem*'.

2.00 p.m. Chairman: The PRESIDENT. Paper: Mr. W. J. B. Houston and Mr. M. W. Miller: '*Cements for Orthodontic Use*'.

2.30 p.m. Paper: Professor Anders Lundström: '*Changes in the Crowding and Spacing of the Teeth with Age*'.

3.15 p.m. Tea.

3.45 p.m. Table Demonstrations.

7.30 p.m. for 8.00 p.m. Banquet—Cafe Royal, Regent Street, London, W.1.

Table Demonstrations:—

Mr. J. R. Halden: '*The Double-coil Sectional Arch*'.

Mr. J. P. Moss and Mr. B. H. Miller: '*Surgical Correction of Orthodontic Problems*'.

Mr. H. S. Orton: '*A Movable Self-contained Orthodontic Bench*'.

Mr. N. R. E. Robertson: '*An Assessment of Early Bone Grafting in Cleft Lip and Palate*'.

Mr. D. Seel: '*Soft-tissue Hazards of Orthodontic Therapy*'.

Mr. J. C. Stephenson: '*A "Trouble-free" Tube Attachment for Removable Appliance Extra-oral Traction*'.

The following demonstrations were open for inspection throughout the Meeting:—

Mr. C. P. Adams: '*A Versatile Clinical, Studio, and Laboratory Photographic Unit*'.

Mr. B. C. Leighton: '1908 *and the Inaugural Meeting of the Society*'.

Saturday, 11 May

9.30 a.m. Chairman: The PRESIDENT. Paper: Mr. E. D. Fulstow: '*The Early Treatment of Angle's Class II, Division 1 Malocclusion*'.

10.00 a.m. Chairman: Professor C. F. Ballard. Paper: Mr. J. D. Atherton: '*The Effect of Orthodontic Tooth Movement upon the Gingival Epithelium*'.

10.45 a.m. Coffee.

11.15 a.m. Chairman: The PRESIDENT. Paper: Mr. C. P. Adams: '*A New Look at the Growth and Development of the Skull, Jaws, and Dental Arches*'.

Closure of the Meeting and Introduction of the new President.

The PRESIDENT said that the Council continued to keep the Society a lively one and welcomed suggestions from all members about what should or should not be done. It was hoped that the liaison between the B.S.S.O. and local orthodontic societies in different parts of Britain would be increased. More meetings held away from London might be one way. Another might be to have some of the papers read in London read again at the expense of the Society to another orthodontic society in a locality remote from the speaker's home. This was one of the projects which the Council was considering.

Another very pressing question was how the Society was to honour the many senior members who had rendered good services to orthodontics. Should they create a number of vice-presidents who would not be expected to become president but would assume the chair at certain meetings?

On behalf of all those present, he thanked all the members of the Council for the increasing work they did. Members would wish him to name Professor Leighton, whose historical researches had proven invaluable; Dr. Mills, who must accept the credit for the high standard of papers which was the lifeblood of the Society; Mr. Rose for turning an apparent deficit into a credit, and Mr. Campbell for carrying the immense burden of organising all the Society's meetings and especially the 60th Anniversary Meeting.

It was his duty and very great pleasure to install Mr. T. Jason Wood as President of the British Society for the Study of Orthodontics.

The retiring President then invested Mr. T. Jason Wood with the Jewel of Office.

A vote of thanks to the retiring President was proposed by Miss R. Caseley and passed by acclamation.

The PRESIDENT (Mr. T. Jason Wood) thanked members for electing him to this high office. He announced that the next meeting would be at Manson House on Monday, 14 October, when he would deliver his Presidential Address. He then declared the meeting closed.

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

Balance Sheet and Income and Expenditure Sheet

FOR THE

YEAR ENDED 31 DECEMBER, 1967

COLE, DICKIN & HILLS,
CHARTERED ACCOUNTANTS, AUDITORS
18, Essex Street, Strand, London, W.C.2

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

INCOME AND EXPENDITURE ACCOUNT for the Year ended 31st December, 1967

5 mths. ended 31.12.1966.			£ s. d.	£ s. d.
£	£			
11		To *Museum Rent*		10 10 0
		,, *Meeting Expenses:—*		
60		Hire of Hall	54 0 0	
96		Refreshments	135 12 0	
166		Reporting	168 2 0	
18		Lanterns and Films	18 4 0	
123		Country Meeting (net) ..	21 7 7	
52		Northcroft Memorial Lecture	52 10 0	
515	——		———	449 15 7
26		,, *Chapman Prize* (1967)		26 5 0
		,, *Printing*		
	1284	Publications	1150 0 0	
	267	General Printing and Stationery	270 11 10	
1551	——		———	1420 11 10
25		,, *Library and Journals*		37 16 0
119		,, *Postage*		122 14 5
234		,, *Secretarial Assistance*		200 0 0
13		,, *Honoraria*		7 7 0
52		,, *Accountancy*		73 10 0
5		,, *Insurance*		5 5 0
64		,, *Sundry Expenses*		16 12 9
		,, *Depreciation of Furniture and*		
28		*Equipment*		28 0 0
17		,, *Repairs*		17 6
		,, *Excess of Income over Expenditure*		
—		*for the year*		405 11 4
£2660				£2804 16 5

15 mths. ended 31.12.1966.			£ s. d.	£ s. d.
£	£			
	1837	By *Members' Subscriptions*	1825 3 0	
	15	Arrears Collected	2 10 0	
1852	——		———	1827 13 0
196		,, *Sale of Transactions*		300 11 2
		,, *Overprovision for Publications in*		
—		*previous year*		246 9 6
321		,, *Interest Received and Accrued* ..		302 11 8
139		,, *Income Tax Recoverable* ..		127 11 1
		,, *Excess of Expenditure over Income*		
152		*for the year*		— — —
£2660				£2804 16 5

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

BALANCE SHEET as at 31st December, 1967

31.12.1966. £	£		£ s. d.	£ s. d.
		Accumulated Fund:—		
	5551	Balance at 1st January, 1967 ..	5364 3 10	
	35	*Less*: Net Loss on Sale of Investments	— — —	
	5516		5364 3 10	
	152	Excess of Income over Expenditure (Deficit) for year	405 11 4	
5364				5769 15 2
		Creditors and Reserves:—		
	1150	Publications Printing Reserves ..	2053 10 6	
	92	General Creditors and Accrued Charges	308 6 8	
	92	Subscriptions in Advance ..	115 3 0	
	15	Petty Cash Accounts	26 5 11	
1349				2503 6 1
		P. H. BURKE, J. F. PILBEAM } *Hon. Auditors*		
		J. S. ROSE *Hon. Treasurer*		
£6713				£8273 1 3

31.12.1966. £	£		£ s. d.	£ s. d.
		Fixed Assets:—		
	110	Furniture and Equipment, Balance at 1st October, 1966	110 0 0	
	28	*Less*: Depreciation	56 0 0	
82				54 0 0
		Investments at Cost:—		
	509	£500 5¼% Corporation of London 1976/79	508 10 9	
	502	230 J. & P. Coats, Patons and Baldwins Ltd. £1 Ordinary Shares	502 3 6	
	1195	1200 National Savings Certificates (Value)	1281 13 4	
	455	£218 British Insulated Callenders Cables Ltd. Ordinary Stock ..	455 2 5	
	478	£50 Royal Insurance Co. Ltd. Stock	478 10 0	
	151	£150 British Insulated Callenders Cables Ltd. 7% Debenture Stock 1985/90	151 4 0	
	761	£700 Sun Alliance and London Insurance Ltd. 6½% Loan Stock 1980/85	760 13 7	
	745	£675 Fisons Ltd. 6½% Loan Stock 1985/90	744 12 0	
	751	£650 Baker Perkins Holdings Ltd. 6¾% Loan Stock 1982/85 ..	750 19 8	
	783	£750 Boulton & Paul Ltd. 7% Loan Stock 1981/91	782 16 9	
6330				6416 6 0
		(Approximate Market Value at 31st December, 1967 £6910)		
177		*Income Tax Recoverable*		219 18 1
14		*Prepayments and Dividends Receivable*		28 3 10
		Cash at Bank:—		
	88	Westminster Bank Ltd.	532 2 2	
	18	P.O.S.B.	18 8 11	
	—	Deposit Account	1000 0 0	
106				1550 11 1
4		*Cash in Hand*		4 2 3
£6713				£8273 1 3

We have prepared the above Balance Sheet and Accounts from the books, records and information given to us and we certify them to be in accordance therewith. We have verified the investments and cash at Bank.

18, Essex Street, Strand, London, W.C.2.
20th March, 1968

COLE, DICKIN & HILLS
Chartered Accountants

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